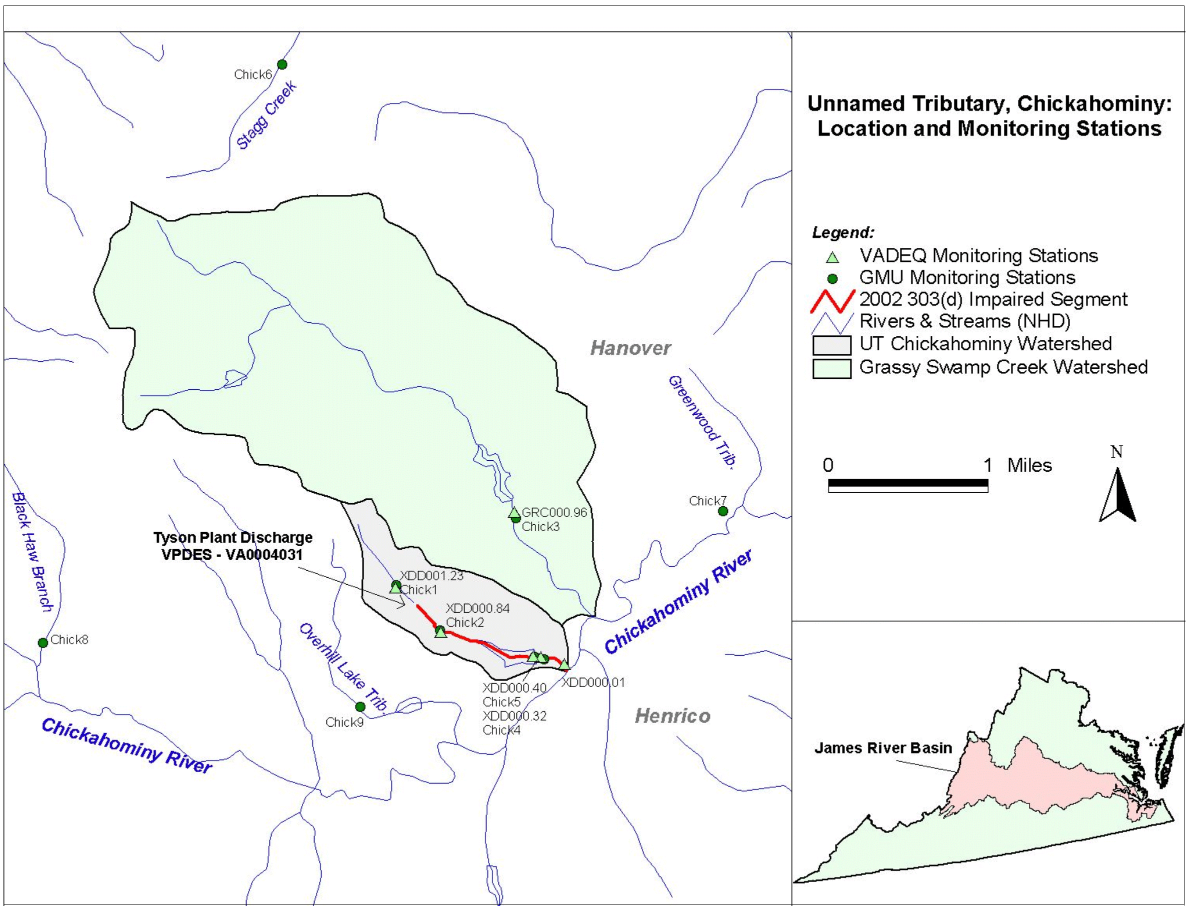
Total Maximum Daily Load (TMDL) Development for the Unnamed Tributary to the Chickahominy River

Aquatic Life Use (Benthic) Impairment



Prepared by:

George Mason University

Tetra Tech, Inc. Fairfax, Virginia

April 2004

Prepared for:

Virginia Department of Environmental Quality

Acknowledgments

Special thanks to the following people who provided assistance on this project:

Mark Alling	VADEQ - Piedmont Regional Office
Chris French	VADEQ - Piedmont Regional Office
Jutta Schneider	VADEQ - Central Office
David Lazarus	VADEQ - Central Office
Charles Martin	VADEQ - Central Office
David Loch	VADEQ - Central Office

Also, thanks to all the local and state environmental personnel and watershed stakeholders that participated throughout the TMDL development process.

George Mason University, Department of Environmental Science and Policy and Tetra Tech, Inc. of Fairfax, Virginia, supported this study through funding provided by the Virginia Department of Environmental Quality.

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Executive Summary

Background

The Unnamed Tributary to the Chickahominy River (UT Chickahominy) watershed (WBID: VAP-G05R-01) is located in the James River Basin in Hanover County, Virginia (USGS Hydrologic Unit Code, 02080206) (Figure 1.1). The watershed lies just north of Richmond, Virginia and approximately 2 miles west of Hunton, Virginia. The unnamed tributary flows southeastward to the Chickahominy River and includes three small impoundments. The total area of the UT Chickahominy watershed is approximately 435 acres.

Virginia 305(b)/303(d) guidance states that support of the aquatic life beneficial use is determined by the assessment of conventional pollutants (dissolved oxygen, pH, and temperature); toxic pollutants in the water column, fish tissue and sediments; and biological evaluation of benthic community data (VADEQ 1997). Benthic community assessments are, therefore, used to determine compliance with the General Criteria section of Virginia's Water Quality Standards (9 VAC 25-260-20). In general, the stream reach that a biomonitoring station represents is classified as impaired if the EPA's Rapid Bioassessment Protocol (RBP) ranking is either moderately or severely impaired. As a result, the UT Chickahominy was listed as impaired on Virginia's Section 303(d) Total Maximum Daily Load Priority List and Report due to violations of the General Standard (Benthics) (VADEQ 1998 and 2002). The impaired segment is approximately 1.49 miles in length from the Tyson Plant discharge to the Chickahominy River confluence.

Water quality data analyses and field observations indicate that the primary cause of the benthic community impairment in the UT Chickahominy is excess phosphorus and high pH conditions. In order to improve water quality conditions that have resulted in benthic community impairments, Total Maximum Daily Loads (TMDLs) were developed for the impaired stream, taking into account all sources of phosphorus in the watershed, plus an implicit margin of safety (MOS).

Upon implementation, the TMDL will ensure that water quality conditions relating to benthic impairment will meet the acceptable nutrient (phosphorus) levels determined by the model developed by Reckhow (1988). This will lead to a reduction in eutrophic conditions in the UT Chickahominy and the downstream pond, specifically.

Sources of Phosphorus

Sources of nutrients can be divided into point and nonpoint sources. There is currently one individually permitted facility in the UT Chickahominy watershed. The Tyson Foods Incorporated processing plant (VPDES VA0004031) is the only point source facility located in the UT Chickahominy watershed. This facility discharges to UT Chickahominy 0.3 miles upstream of DEQ biomonitoring station 2-XDD000.84. The current design flow of the facility is 1.4 MGD. Table 1 presents the permit limits for the Tyson Foods Incorporated processing plant.

Table 1. Permit limits for the Tyson Foods discharge permit (VA0004031)

Outfall	Parameter Code	Parameter Description	Conc. Unit	Quantity Unit	Quantity Avg. (monthly)	Quantity Max. (daily)	Conc. Min. (daily)	Conc. Avg. (monthly, except FC)	Conc. Max. (daily)
1	1	FLOW		MGD	NL	NL	*********	*********	*********
	2	PH	SU		*********	*********	6	*********	9
	3	BOD5	MG/L	KG/D	28.4	NL	*********	6	8
	4	TSS	MG/L	KG/D	23.7	NL	*********	5	7.5
	6	COLIFORM, FECAL	N/CML		*********	*********	*********	200 (Geo Mean)	NL
	7	DO	MG/L		*********	*********	5	*********	*********
	12	PHOSPHORUS, TOTAL (AS P)	MG/L	KG/D	1.4	2.4	*********	0.3	0.5
	13	NITROGEN, TOTAL AS N	MG/L	KG/D	NL	NL	*********	NL	NL
	39	AMMONIA, AS N	MG/L	KG/D	9.5	NL	*********	2	NL
	71	SETTLEABLE SOLIDS	ML/L		*********	*********	*********	0.1	NL
	165	CL2, INST RES MAX	PPB		*********	*********	*********	7.97	16.09
	500	OIL & GREASE	MG/L	KG/D	47.3	71	*********	10	15
2	1	FLOW		MG	NL	NL	*********	*********	*********
	2	PH	SU		*********	*********	NL	*********	NL
	3	BOD5	MG/L		*********	*********	*********	*********	NL
	4	TSS	MG/L		*********	*********	*********	*********	NL
	6	COLIFORM, FECAL	N/CML		*********	*********	*********	*********	NL
	12	PHOSPHORUS, TOTAL (AS P)	MG/L		*********	*********	*********	*********	NL
	39	AMMONIA, AS N	MG/L		*********	*********	*********	*********	NL
	68	TKN (N-KJEL)	MG/L		*********	*********	*********	*********	NL
	500	OIL & GREASE	MG/L		*********	*********	*********	*********	NL

CODES: NL = No Limit

Phosphorus, because of its tendency to adsorb to soil particles and organic matter, is primarily transported in surface runoff with eroded sediment. Under normal conditions, phosphorus is scarce in the aquatic environment; however, land disturbance activities and fertilizer applications increase nutrient loading in surface waters. Nonpoint sources of phosphorus include soil erosion, runoff from urban and agricultural lands, animal waste, residential septic systems, and groundwater.

Modeling

TMDLs were developed using BasinSim 1.0 and the GWLF model for nonpoint source loads, in addition to the calculations done to include phosphorus loads from waterfowl and the point source. GWLF is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for total phosphorus, based on daily water balance totals that are summed to give monthly values.

Daily streamflow data are needed to calibrate watershed hydrologic parameters in the GWLF model. The USGS streamflow gage (02036500), located on Fine Creek at Fine Creek Mills, VA, was used to calibrate hydrology for the UT Chickahominy watershed. The calibration period was April 1, 1991 - September 30, 2002. The calibration period covered a range of hydrologic conditions, including low- and high-flow conditions as well as seasonal variations. The calibrated GWLF model adequately simulated the hydrology of the impaired watershed.

TMDL development requires the identification of impairment causes and the establishment of numeric endpoints that will allow for the attainment of designated uses and water quality criteria. Numeric endpoints represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. Virginia does not currently have numeric criteria for nutrients (i.e., total phosphorus and total nitrogen), sediment, and other parameters that may be contributing to the impaired condition of the benthic community in these streams. Therefore, the TMDL endpoint for phosphorus was developed using a model developed by Reckhow (1988) in a study of southeastern lakes and reservoirs that predicts ambient total phosphorus concentrations in lakes based on phosphorus inputs, hydraulic detention time, and mean depth. This model was selected to simulate eutrophic conditions in the pond located on the UT Chickahominy impaired segment and downstream of the point source discharge. Phosphorus inputs to the model include the nonpoint source load, the point source load, and a load from wildlife.

Existing Conditions

The impaired watershed model was calibrated for hydrology using different modeling periods and weather input files. For TMDL calculation the calibrated impaired watershed was modeled for an 11-year period from 4/1/1991 to 3/31/2002. The 11-year means for total phosphorus were determined for each land use/source category in the watershed. This modeling period was used, after calibration, to represent a broad range of recent weather and hydrologic conditions. The nutrient loads from all nonpoint sources, including waterfowl, were then added to the point source load in order to determine the total annual phosphorus load to the UT Chickahominy.

Margin of Safety

While developing allocation scenarios for the TMDL, an implicit margin of safety (MOS) was included in the TMDL. Conservative assumptions and other considerations were used in developing the TMDL to account for any uncertainty in the data and the computational methodology used for the analysis, as well as provide an additional level of protection for designated uses.

Allocation Scenarios

Load or wasteload allocations were assigned to each source category in the watersheds, based on the results of the Reckhow model. Several allocation scenarios were developed for the UT Chickahominy watershed to examine the outcome of various load reduction combinations. The recommended scenario for UT Chickahominy (Table 2) is based on maintaining the existing percent load contribution from each source category. One additional scenario is presented for comparison purposes (Table 3). In this alternative scenario, load reductions were made to the point source load only. The recommended scenario balances the reductions from all sources by maintaining existing watershed loading characteristics. In each scenario, loadings from certain source categories were allocated according to their existing loads. For instance, phosphorus loads from forest lands represent the natural condition that would be expected to exist; therefore, the loading from forest lands was not reduced.

Table 2. Recommended phosphorus allocations for the UT Chickahominy

Source Category	Phosphorus Load Allocation (lbs/yr)	Phosphorus % Reduction
Pasture/Hay	0.99	68.0%
Cropland	1.98	68.0%
Transitional	2.96	68.0%
Water	0.00	0.0%
Forest	0.44	0.0%
Urban	4.02	68.0%
Groundwater	9.04	0.0%
Point Source	409.35	68.0%
Wildlife	3.92	68.0%
TMDL Load	432.69	67.5%

Table 3. Alternative phosphorus allocation scenario for the UT Chickahominy

Source Category	Phosphorus % Reduction
Pasture/Hay	0.0%
Cropland	0.0%
Transitional	0.0%
Water	0.0%
Forest	0.0%
Urban	0.0%
Groundwater	0.0%
Point Source	70.2%
Wildlife	0.0%

The TMDLs established for this stream consists of a point source wasteload allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS).

The TMDL equation is as follows:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis.

The nutrient loads from all nonpoint sources, including waterfowl, were added to the point source load in order to determine the total annual phosphorus load to the UT Chickahominy. A phosphorus TMDL were then developed for the impaired stream segment based on the calculated endpoint and the results from the recommended load allocation scenario (Table 4).

Table 4. Phosphorus TMDL for the UT Chickahominy

TMDL (lbs/yr)	LA (lbs/yr)	WLA (lbs/yr)	MOS (lbs/yr)	Overall % Reduction
432.69	23.34	409.35 (*Tyson Foods Incorporated*)	0 (implicit)	67.5%

SECTION 1

INTRODUCTION

1.1 Background

1.1.1 TMDL Definition and Regulatory Information

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources (USEPA 1991).

1.1.2 Impairment Listing

The Unnamed Tributary to the Chickahominy River (UT Chickahominy) is listed as impaired on Virginia's Section 303(d) Total Maximum Daily Load Priority List and Report due to violations of the General Standard (Benthics) (VADEQ 1998 and 2002a). The downstream segment of the UT Chickahominy was placed on Virginia's Section 303(d) list in 1998 for partial support of the Aquatic Life Use. The benthic community downstream of the Tyson Plant (VPDES Permit No. VA0004031) discharge is considered moderately impaired when compared to the benthic community immediately upstream of the discharge. The impaired segment is approximately 1.49 miles in length from the Tyson Plant discharge to the Chickahominy River confluence.

The Aquatic Life Use is impaired due to benthic assessments conducted since 1994. The suspected source, according to the 2002 303(d) Impaired Waters Fact Sheet, is considered unknown. Additional monitoring downstream of the Tyson Plant was recommended in the 1998 assessment to further characterize the cause and source of the impairment. This assessment also stated that biological monitoring reports indicate that the source of impairment may either be the Tyson Plant or nonpoint source run-off from the Tyson Plant parking lot.

1.1.3 Watershed Location

The UT Chickahominy watershed (WBID: VAP-G05R-01) is located in the James River Basin in Hanover County, Virginia (USGS Hydrologic Unit Code, 02080206) (Figure 1.1). The watershed lies just north of Richmond, Virginia and approximately 2 miles west of Hunton, Virginia. The unnamed tributary flows southeastward to the Chickahominy River. The total area of the UT Chickahominy watershed is approximately 435 acres.

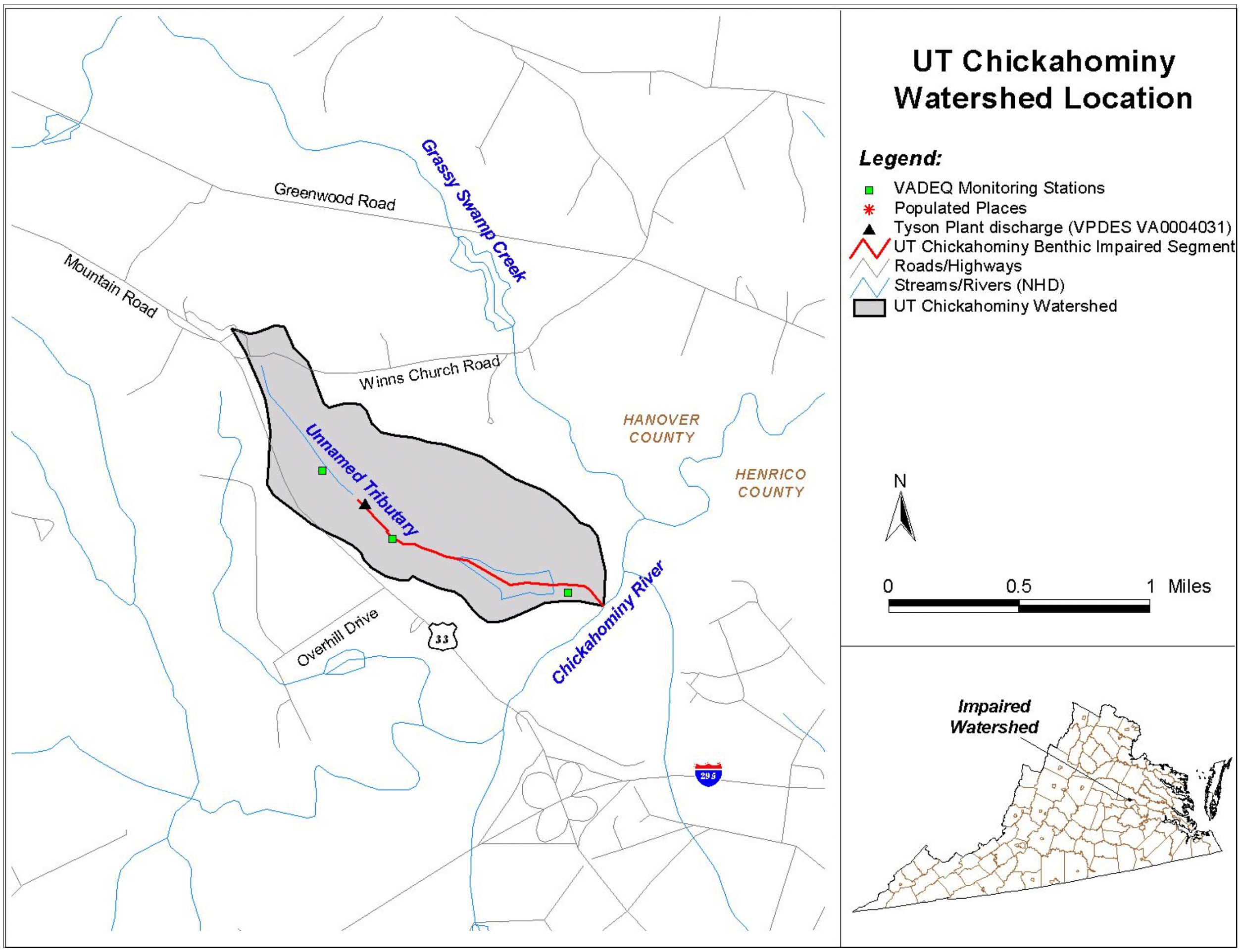

Figure 1.1 Location of TMDL watershed

1.2 Designated Uses and Applicable Water Quality Standards

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term "Water quality standards" *means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and* *serve the purposes of the State Water Control Law (§ 62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC § 1251 et seq.).*

1.2.1 Designation of Uses (9 VAC 25-260-10)

A. All state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish).

The UT Chickahominy does not support the aquatic life designated use due to violations of the general (benthic) criteria (see Section 1.2.2).

1.2.2 Water Quality Standards

General Criteria (9 VAC 25-260-20)
A. All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.

Specific substances to be controlled include, but are not limited to: floating debris, oil scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled.

1.3 Biomonitoring and Assessment

Direct investigations of biological communities using rapid bioassessment protocols, or other biosurvey techniques, are best used for detecting aquatic life impairments and assessing their relative severity (Plafkin et al. 1989). Biological communities reflect overall ecological integrity; therefore, biosurvey results directly assess the status of a waterbody relative to the primary goal of the Clean Water Act. Biological communities integrate the effects of different pollutant stressors and thus provide a holistic measure of their aggregate impact. Communities also integrate the stresses over time and provide an ecological measure of fluctuating environmental conditions.

Many state water quality agencies use benthic macroinvertebrate community data to assess the biological condition of a waterbody. Virginia uses EPA's Rapid Bioassessment Protocol (RBP II) to determine the status of a stream's benthic macroinvertebrate community. This procedure relies on comparisons of the benthic macroinvertebrate community between a monitoring station and its designated reference site. Measurements of the benthic community, called metrics, are used to identify differences between monitored and reference stations. Metrics used in the RBP II protocol include taxa richness, percent contribution of dominant family, and other measurements that provide information on the abundance of pollution tolerant versus pollution intolerant organisms. Biomonitoring stations are typically sampled in the spring and fall of each year. The biological condition scoring criteria and the bioassessment matrix are discussed in the technical document, *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish* (Plafkin et al. 1989). The RBPII bioassessment scoring matrix is presented in Table 1.1.

Table 1.1 Bioassessment scoring matrix (Plafkin et al. 1989)

% Compare to Reference Score (a)	Biological Condition Category	Attributes
>83%	Non-Impaired	Optimum community structure (composition and dominance).
54 - 79%	Slightly Impaired	Lower species richness due to loss of some intolerant forms.
21 - 50%	Moderately Impaired	Fewer species due to loss of most intolerant forms.
<17%	Severely Impaired	Few species present. Dominant by one or two taxa. Only tolerant organisms present.
(a) Percentage values obtained that are intermediate to the above ranges require subjective judgement as to the correct placement.		

Virginia 305(b)/303(d) guidance states that support of the aquatic life beneficial use is determined by the assessment of conventional pollutants (dissolved oxygen, pH, and temperature); toxic pollutants in the water column, fish tissue and sediments; and biological evaluation of benthic community data (VADEQ 2002b). Benthic community assessments are, therefore, used to determine compliance with the General Criteria section of Virginia's Water Quality Standards (9 VAC 25-260-20). In general, the stream reach that a biomonitoring station represents is classified as impaired if the RBP ranking is either moderately or severely impaired. As a result, the UT Chickahominy was listed as impaired due to violations of the general standard (aquatic life).

SECTION 2

TMDL WATERSHED CHARACTERIZATION

2.1 Watershed Characterization

2.1.1 General Information

The UT Chickahominy watershed is located in Hanover County, Virginia, in the James River Basin (USGS Hydrologic Unit Code, 02080206) (Figure 1.1). The watershed lies just north of Richmond, Virginia and approximately 2 miles west of Hunton, Virginia. The waterbody identification code (WBID, Virginia Hydrologic Unit) is VAP-G05R-01. The impaired stream length is approximately 1.49 miles and extends from the Tyson Plant discharge to its confluence with the Chickahominy River. The total area of the UT Chickahominy watershed is approximately 435 acres.

2.1.2 Geology

The UT Chickahominy is located in the Piedmont physiographic province. The Piedmont physiographic province is the largest physiographic province in Virginia. It is bounded on the east by the Fall Zone, which separates the province from the Coastal Plain, and on the west by the mountains of the Blue Ridge province. The province is characterized by gently rolling topography and deeply weathered bedrock. Rocks are strongly weathered in the Piedmont's humid climate and bedrock is generally buried under a thick (2-20 m) blanket of saprolite Outcrops are commonly restricted to stream valleys where saprolite has been removed by erosion. The predominant rocks found in the region are gneiss, schist, and granite, of which quartz, feldspar, and mica are the primary minerals. Igneous and metamorphic rocks with a high base content of calcium and magnesium are also found in lesser quantities.

2.1.3 Soils

Soils data were obtained from the State Soil Geographic (STATSGO) database which includes general soils data and map unit delineations for the United States. GIS coverages provide accurate locations for the soil map units (MUIDs) at a scale of 1:250,000 (NRCS 1994). A map unit is composed of several soil series having similar properties. STATSGO map units that cover the area of the UT Chickahominy watershed are shown in Figure 2.1. The following soil series descriptions are based on NRCS Official Soil Descriptions (1998-2002).

There is only one soil type in the UT Chickahominy watershed. STATSGO Soil Type VA041 is composed of the Colfax series, the Vance series, the Helena series, the Bourne series, and the Orange series. The Colfax series accounts for most of the map unit. The Colfax series consists of very deep, somewhat poorly drained soils formed in materials weathered from granitic rocks. These soils are on the divides at the base of hills and sideslopes of Piedmont uplands. Permeability is moderate in the upper part of the solum and slow in the fragipan. Slopes range from 0 to 15 percent.

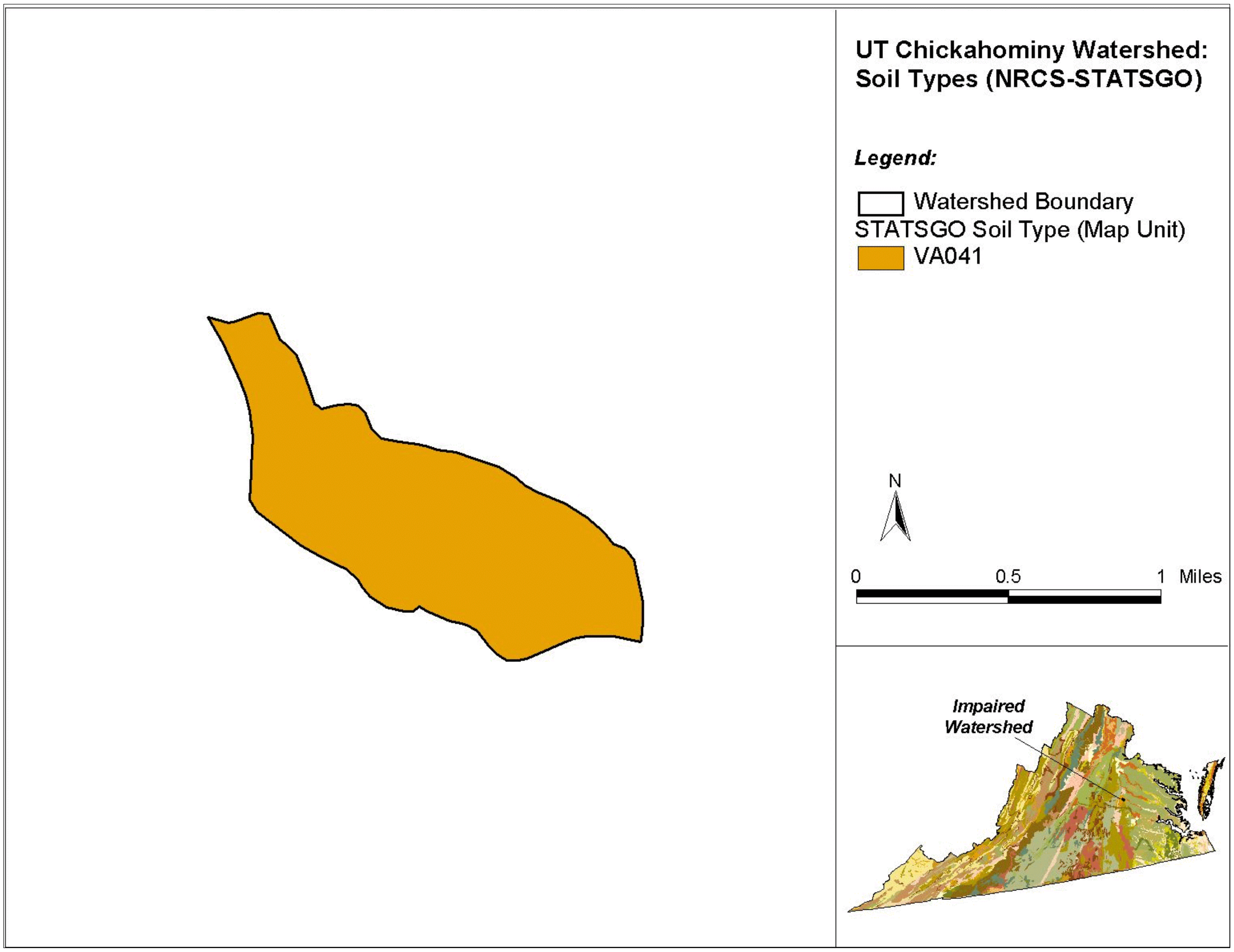

Figure 2.1 STATSGO soil types in the UT Chickahominy watershed

2.1.4 Climate

The area's climate is typical of other mid-eastern Piedmont areas in Virginia. Weather data for this watershed can be characterized using the Ashland 1 SW meteorological station (NCDC), which is located approximately 4.8 miles northeast of the watershed (period of record: 1948-2003). The growing season lasts from April 17 through October 21 in a typical year (SERCC 2003). Average annual precipitation is 42.51 inches with July having the highest average precipitation (4.31 inches). Average annual snowfall is 15.4 inches, most of which occurs in January and February. The average annual maximum and minimum daily temperature is 68.0ºF and 45.2ºF, respectively. The highest monthly temperatures are recorded in July (87.0ºF - avg. maximum) and the lowest temperatures are recorded in January (46.4ºF - avg. minimum).

2.1.5 Land Use

General land use/land cover data for the UT Chickahominy watershed was extracted from the Multi-Resolution Land Characterization (MRLC) database for the state of Virginia (USEPA 1992) and is shown in Figure 2.2. This database was derived from satellite imagery taken during the early 1990s and is the most current detailed land use data available. Land uses in the watershed include various urban, agricultural, and forest categories (Table 2.1 and Figure 2.2). Approximately 67% of the watershed is forested, while over 14% of the watershed is used for agricultural purposes. Transitional lands (areas of sparse vegetative cover that are changing from one land use to another) account for almost 10% of the watershed, while commercial development accounts for about 6% of the watershed.

Table 2.1 MRLC and consolidated land uses in the UT Chickahominy watershed

MRLC Land Use	Area (acres)	Percent	Consolidated Land Use	Area (acres)	Percent
Woody Wetlands	7.6	1.74%	Forest	289.6	66.66%
Emergent Herbaceous Wetlands	9.8	2.25%			
Deciduous Forest	168.4	38.76%			
Evergreen Forest	5.6	1.28%			
Mixed Forest	98.3	22.63%			
Open Water	13.6	3.12%	Water	13.6	3.12%
Pasture/Hay	56.7	13.06%	Pasture/Hay	56.7	13.06%
Row Crops	6.7	1.54%	Cropland	6.7	1.54%
Transitional	40.5	9.32%	Transitional	40.5	9.32%
High Intensity Commercial/Industrial/Transportation	13.7	3.15%	Urban (Includes I & P)	27.4	6.30%
High Intensity Commercial/Industrial/Transportation-Imp	13.7	3.15%			
Total	434.4	100.00%	Total	434.4	100.00%

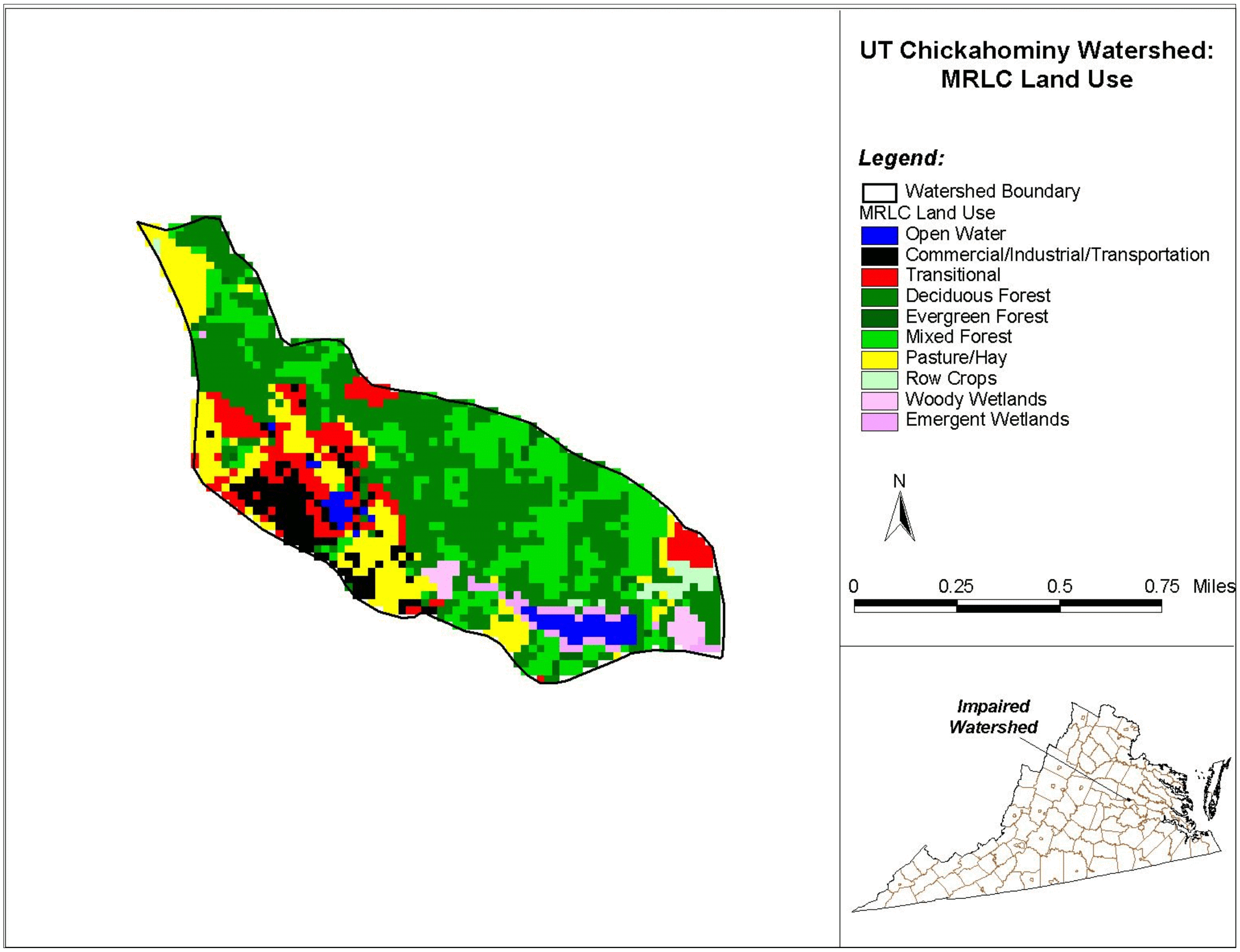

Figure 2.2 MRLC land use in the UT Chickahominy watershed

2.1.6 Ecoregion

The UT Chickahominy watershed is located in the Piedmont ecoregion - Level III classification 45 (Woods et al. 1999). This ecoregion extends from Wayne County, Pennsylvania, southwest through Virginia. It is characterized by irregular plains, low rounded hills and ridges, shallow valleys and scattered monadnocks. It is mostly forested and is a transition zone between the mountainous ecoregions to the west and the flatter coastal ecoregions to the east. The Piedmont is underlain with deeply weathered, deformed metamorphic rocks with intrusions by igneous material. The humid, warm temperate climate originally supported Oak-Hickory-Pine forests with much of the forest lost to agriculture, causing significant soil loss. Today many abandoned fields are reverting to forest. Stream gradients are typically low to moderate with the moderate gradient streams concentrated in the hillier areas. Falls, islands and rapids and associated fish assemblages are found along the eastern border of the Piedmont in the Fall Zone.

At a finer scale, the UT Chickahominy watershed is located in the Northern Outer Piedmont subecoregion - Level IV classification, 45f (Woods et al. 1999) (Figure 2.3). The Northern Outer Piedmont subecoregion is characterized by low rounded ridges and shallow ravines on an irregular plain. The subecoregion is underlain by deformed, deeply weathered gneissic rock with intrusions by plutons and is veneered with saprolite. Stream flow velocities tend to be moderately slow with both riffles and runs short and infrequent. Stream substrates are composed mainly of sand, silt, clay and detritus. The vegetation is classified as Oak-Hickory-Pine Forest with hickory, shortleaf pine, loblolly pine, white oak and post oak dominating. Local relief varies from 100 to 250 feet.

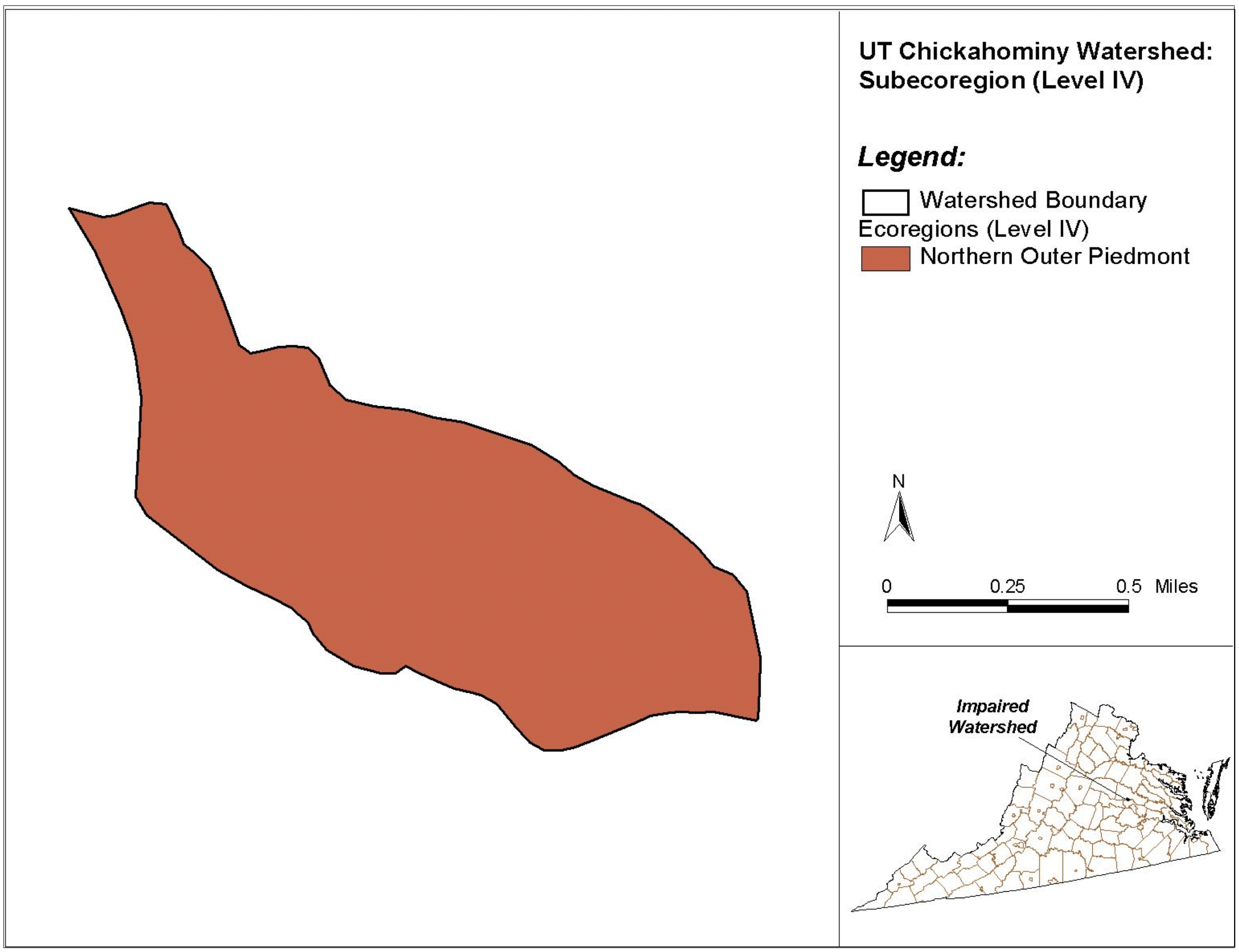

Figure 2.3 Level IV ecoregions in the UT Chickahominy watershed

2.2 Biomonitoring Assessment

Tetra Tech, VADEQ, and USEPA recently developed the Virginia Stream Condition Index (VaSCI), which provides a more detailed and reliable assessment of the benthic macroinvertebrate community in Virginia's non-coastal, wadeable streams (USEPA 2003). This index allows for the evaluation of biological condition in the impaired watershed and can be used to measure improvements in the benthic macroinvertebrate community in the future. VADEQ and GMU biomonitoring data were used to calculate the VaSCI scores shown in Table 2.2. These scores are less than the VaSCI recommended impairment threshold of 61.

The VaSCI is a multi-metric biological index designed to measure stream health against a reference condition in lieu of upstream or watershed control stations. This index was applied to biological data collected on the UT Chickahominy in an attempt to measure the potential effects to the stream segment below the Tyson point source discharge. Comparisons of VaSCI scores calculated from biological data collected by GMU in Spring and Fall 2003 at stream reaches above (XDD001.23) and below (XDD000.84) the Tyson discharge and below the downstream pond on the UT Chickahominy (XDD000.32) were similar and were all below the reference condition. However, the VaSCI is still in the developmental stage. Presently, VADEQ has assembled an Academic Advisory Committee (AAC) to review the technical merits of this assessment method and to make recommendations for further testing of the index to ensure its applicability in assessing biological data from a wide range of stream types. Therefore, this index, as it stands, may not be suited for the unusual UT Chickahominy stream segment in question.

Table 2.2 Biomonitoring index scores for the UT Chickahominy

StationID	Organization	Stream	Sample Date	VaSCI Index Score
XDD000.84	DEQ	UT Chickahominy	11/22/1994	9
			05/01/1995	28
			05/06/1996	32
			10/23/1996	33
			05/19/1997	31
			11/12/1997	36
			05/24/1998	31
			04/16/2002	33
			09/24/2002	29
Chick2	GMU		04/04/2003	26
			11/18/2003	28
			Average	29
XDD001.23	DEQ	UT Chickahominy	11/22/1994	24
			05/01/1995	25
			05/06/1996	23
			10/23/1996	20
			05/19/1997	32
			11/12/1997	31
			05/24/1998	17
Chick1	GMU		04/04/2003	25
			11/18/2003	26
			Average	25
XDD000.32	DEQ	UT Chickahominy	07/01/2002	21
			09/23/2002	17
Chick4	GMU		11/17/2003	29
			Average	22
GRC000.96	DEQ	Grassy Swamp Creek	07/01/2002	47
			09/24/2002	32
			Average	40

SECTION 3

STRESSOR IDENTIFICATION

3.1 Stressor Identification Process

Biological assessments are useful in detecting impairment, but they do not necessarily identify the cause(s) of impairment. EPA developed the *Stressor Identification: Technical Guidance Document* to assist water resource managers in identifying stressors or combinations of stressors that cause biological impairment (Cormier et al. 2000). Elements of the stressor identification process were used to evaluate and identify the primary stressors of the benthic community in the Unnamed Tributary to the Chickahominy River (UT Chickahominy). Watershed and water quality data from this stream, reference watershed data, and field observations were used to help identify candidate causes.

3.2 Candidate Causes

Based on information provided by VADEQ and watershed data collected at the beginning of the TMDL study, it was hypothesized that high nutrient concentrations, habitat alteration, and other possible factors were responsible for the listed benthic impairment. The high number of pollution-tolerant organisms indicate poor water quality and aquatic life conditions. A field visit to the UT Chickahominy watershed was conducted by Tetra Tech, VADEQ, and George Mason University (GMU) personnel on April 4, 2003 to gather information on stream and watershed characteristics for stressor identification and modeling studies and to take benthic and water quality samples. GMU personnel later visited the site on November 17 and 18, 2003 to collect additional water quality data and benthic samples for analysis. VADEQ also collected additional samples and field data on December 4, 5, and 18, 2003 and in January and February 2004. Field observations and stressor analyses confirmed the likelihood that high nutrient inputs were primarily responsible for negative impacts to the benthic macroinvertebrate community. Potential stressors and their relationship to benthic community condition are discussed below.

3.2.1 Temperature

Temperature affects the metabolic rates of aquatic organisms, photosynthesis of aquatic plants, parasites, pathogens, and can influence the toxicity of some pollutants. In addition, higher water temperatures reduce the oxygen saturation capacity of the water, which can have negative effects on organisms that require a certain amount of dissolved oxygen to sustain life.

Humans can influence water temperature by direct thermal pollution, altering land cover and land use within a watershed, or removing vegetation within the riparian zone. Temperature can also be increased by increasing turbidity, which allows more solar radiation to be absorbed by the water.

3.2.2 pH

pH can negatively affect organisms when it is both too high and too low. As a result, an appropriate pH level for healthy stream ecosystems is often considered to be between 6.0 and 9.0 standard units. Low pH conditions (acidity) can be caused by various sources including runoff, acidic precipitation and deposition, and point source discharges. High pH is often associated with excess primary production of algae, which alters the balance of carbonates in the water. In Virginia streams, low pH is typically a more common problem than high pH.

pH levels outside the acceptable range can cause numerous secondary impacts as well. For example, when pH is low, aluminum ions can be mobilized and attach to the gills of freshwater organisms, resulting in decreased respiratory efficiency and, in some cases, mortality. In the case of high pH, the level of unionized ammonia in the water column increases resulting in potential toxic impacts to aquatic organisms. Reduced emergence and mortality of stoneflies, mayflies, and dragonflies at pH levels greater than 9.5 has also been noted in freshwater studies (NAS/NAE 1972).

3.2.3 Low Dissolved Oxygen

Organic enrichment can cause low dissolved oxygen (DO) levels which stress benthic organisms. In general, high nitrogen and phosphorus levels can lead to increased production of algae and macrophytes, which can result in the depletion of oxygen in the water column through metabolic respiration. In addition, at higher water temperatures the concentration of dissolved oxygen is lower because the solubility of oxygen (and other gases) decreases with increasing temperature. Higher water temperatures can be caused by the loss of shading, higher evaporation rates, reduced stream flow, and other factors.

Aquatic organisms, including benthic macroinvertebrates, are dependent upon an adequate concentration of dissolved oxygen. Less tolerant organisms generally cannot survive or are outcompeted by more tolerant organisms under low dissolved oxygen conditions. This process reduces diversity and alters community composition from a natural state. Aquatic insects and other benthic organisms serve as food items for fishes, therefore, alterations in the benthic community can impact fish feeding ecology (Hayward and Margraf 1987; Leach et al. 1977).

3.2.4 Organic Matter

Excess organic matter can directly interfere with the habitat of numerous benthic organisms. In excess amounts, particulate organic matter (POM) can clog the substrate, covering or filling acceptable benthic habitat. Dissolved organic matter (DOM) affects water clarity and nutrient availability. Furthermore, organic matter can alter the pH of water through decomposition and the release of excess nutrients into the aquatic environment can have further negative consequences.

3.2.5 Nutrients

Excess nutrient concentrations have been documented to have numerous secondary negative impacts on aquatic biota. In general, nutrient over-enrichment can lead to eutrophication or hypereutrophication of a waterbody. Under these conditions, algal blooms become more common, sedimentation increases, and there is a pronounced shift in trophic state. Negative consequences can include increased turbidity, a decreased photic zone, local extinction of specialized or intolerant aquatic flora, high pH levels, low dissolved oxygen, and decreased substrate stability.

Excess nutrients in streams are often caused by runoff from agriculture and livestock, direct or “straight pipe” additions, suburban lawns, acid rain, golf courses, and leaky or inefficient septic systems. Although the effects of excessive nutrient concentrations have been documented in various stream assessments, lakes and other larger waterbodies (e.g. Chesapeake Bay), are particularly susceptible to nutrient enrichment due to lower flushing rates and other factors.

3.2.6 Sedimentation

Excessive sedimentation from anthropogenic sources is a common problem that can impact the stream biota in a number of ways. Deposited sediments reduce habitat complexity by filling pools, critical riffle areas, and the interstitial spaces used by aquatic invertebrates. Substrate size is a particularly important factor that influences the abundance and distribution of aquatic insects. Sediment particles at high concentrations can directly affect aquatic invertebrates by clogging gill surfaces and lowering respiration capacity. Suspended sediment also increases turbidity in the water column which can affect the feeding efficiency of visual predators and filter feeders. In addition, pollutants, such as phosphorus, adsorb to sediment particles and are transported to streams through erosion processes.

<u>Habitat Alteration and Riparian Vegetation</u>

Sedimentation and habitat alteration are often directly related. The lack of an adequate riparian buffer along stream sections is often considered to be a potential factor affecting the benthic community. Minimal riparian vegetation was observed in specific areas during field visits. These riparian areas perform many functions that are critical to the ecology of the streams that they border. Functional values include: flood detention, bank stabilization, nutrient cycling, wildlife habitat, and canopy shading which decreases water temperature and increases baseflow through lower evaporation rates.

3.2.7 Toxic Pollutants

Toxic pollutants in the water column and sediment can result in acute and chronic effects on aquatic organisms. Increased mortality rates, reduced growth and fecundity, respiratory problems, tumors, deformities, and other consequences have been documented in toxicity studies of aquatic organisms. Degraded water quality conditions and other environmental stressors can lead to higher rates of incidence of these problems. Most often, toxic pollutants found in high concentrations in freshwater are there due to anthropogenic activities.

3.3 Monitoring Stations

There are four current and historical water quality sampling stations located in the UT Chickahominy watershed; one (2-XDD001.23) is upstream of the Tyson Plant discharge and the benthic-impaired segment; the other three (2-XDD000.84, 2-XDD000.32, and 2-XDD000.01) are located on the benthic-impaired segment. Three stations (2-XDD000.32, 2-XDD000.84 and 2-XDD001.23) are VADEQ biological monitoring stations. In addition to the VADEQ monitoring stations, GMU researchers conducted sampling at four stations on the UT Chickahominy (Chick1, Chick2, Chick4, and Chick5), one station on Grassy Swamp Creek (Chick3), and several stations on other reference streams in the area. Water quality and biomonitoring was conducted at these stations by GMU researchers, as listed in Table 3-1. The types of data associated with each monitoring station are different depending on the program for which sampling was conducted. All of the VADEQ and GMU monitoring stations located on the UT Chickahominy and Grassy Swamp Creek are presented in Table 3-1 and shown in Figure 3-1. The water quality data period shown in Table 3-1 includes field parameters collected during biomonitoring site visits.

Grassy Swamp Creek was used as a reference stream comparison because its larger watershed contributes a greater flow that is more comparable to flow in the UT Chickahominy impaired segment, which is augmented by the Tyson point source discharge. In addition, the Grassy Swamp Creek monitoring station is also located below an impoundment. This provides a more constant flow level that is comparable to UT Chickahominy, downstream of the point source discharge, and offers similar stream/impoundment morphology. Both streams are adjacent tributaries to the Chickahominy River and have similar watershed characteristics (landuse, soils, etc.).

The upstream reference station, XDD001.23, was discontinued in 2002 in favor of the reference station on Grassy Swamp Creek (GRC000.96). This change was made because of the low or zero flow conditions that persisted at the upstream reference site (the contributing watershed is only 70 acres) and because Grassy Swamp Creek was a better reference comparison, as described above. Station XDD0001.23 also has high natural tannic acid levels that affect water quality.

All available water quality, biological, and habitat data collected by VADEQ at monitoring stations in the UT Chickahominy and Grassy Swamp Creek watersheds were used to help characterize stream condition and impairment causes. The data analysis also includes EPA toxicity test results for the UT Chickahominy and additional water quality, biological, and habitat data collected by GMU in support of this study.

The data collected at each station are representative of the conditions at that site. These conditions are affected by pollutant discharges from point and nonpoint sources, impoundments and other physical features, streamflow, land use patterns, watershed characteristics, seasonality, and other factors. Station comparisons were made to help identify potential impairment sources and causes, given the unique characteristics of each site. All of these data are useful in helping to determine the likely impairment sources and causes. Stations XDD000.40 and XDD000.32 are primarily influenced by the downstream impoundment ("farm pond") and upstream water quality. The conditions in the pond and downstream are directly related, in large part, to the physio-chemical makeup of the water that flows into this impoundment. Surface runoff into the pond is negligible, as compared to the contribution from upstream. The eutrophic conditions (pH > 9 and chlorophyll a > 50 mg/m3) that have been noted in and below the pond are related to the high ambient nutrient levels contributed from upstream. Therefore, the data collected at these stations are important in characterizing the nature of biological impairment.

Table 3.1 UT Chickahominy and reference monitoring stations

Stream	Station	Org	Location	WQ Data Period	Biomonitoring Data Period
UT Chickahominy	2-XDD000.01	DEQ	Just above mouth	7/2/03	N/A
	2-XDD000.32	DEQ	Below pond	4/21/03 – 10/20/03	7/1/02 – 9/23/02
	2-XDD000.40	DEQ	Within pond, at dam	8/26/03 – 10/20/03	N/A
	2-XDD000.84	DEQ	Below Tyson Foods discharge	5/24/98 – 10/20/03	1994 – 9/24/02
	2-XDD001.23	DEQ	¼ mile upstream of Tyson Foods discharge	5/24/98 – 10/20/03	1994 - 1998
	Chick1	GMU	Above Tyson Foods discharge (at DEQ station 2-XDD001.23)	4/4/03	4/4/03, 11/18/03
	Chick2	GMU	Below Tyson Foods discharge (at DEQ station 2-XDD000.84)	4/4/03	4/4/03, 11/18/03
	Chick4	GMU	Below pond, off Rt. 33 (at DEQ station 2-XDD000.32)	11/17/03	11/17/03
	Chick5	GMU	At pond, near Chick4	11/17/03	N/A
Grassy Swamp Creek	2-GRC000.96	DEQ	Rt. 660	7/1/02 – 10/20/03	7/1/02 – 9/24/02
	Chick3	GMU	0.85 mile above mouth, below dam (approx. location as DEQ station 2-GRC000.96)	4/4/03	4/4/03

Stream	Station	Org	Location	WQ Data Period	Biomonitoring Data Period
Other potential reference streams	Chick6	GMU	Stagg Creek, at Rt. 657	11/17/03	11/17/03
	Chick7	GMU	Greenwood Tributary, at Rt. 625	11/17/03	N/A
	Chick8	GMU	Black Haw Branch, at Rt. 624	11/18/03	N/A
	Chick9	GMU	Tributary to Overhill Lake, at Oakhill Drive	11/18/03	11/17/03

* Note that GMU personnel sampled UT Chickahominy and several reference streams in the area on November 17 and 18, 2003. VADEQ also conducted additional monitoring at UT Chickahominy stations on December 4, 5, and 18, 2003 (Appendix A). Storm sampling (following a 0.85 inch rainfall event) was conducted by VADEQ on December 5 at 30-meter intervals from the Tyson discharge outfall downstream to the headwaters of the "farm pond" (located near the mouth and shown in Figure 3.1). These data were used to help characterize water quality conditions and point/nonpoint source contributions. Storm sampling stations are not listed in Table 3.1 and shown in Figure 3.1 (refer to Appendix A). Additional sediment samples and pond bathymetry data were collected by VADEQ in January and February 2004.

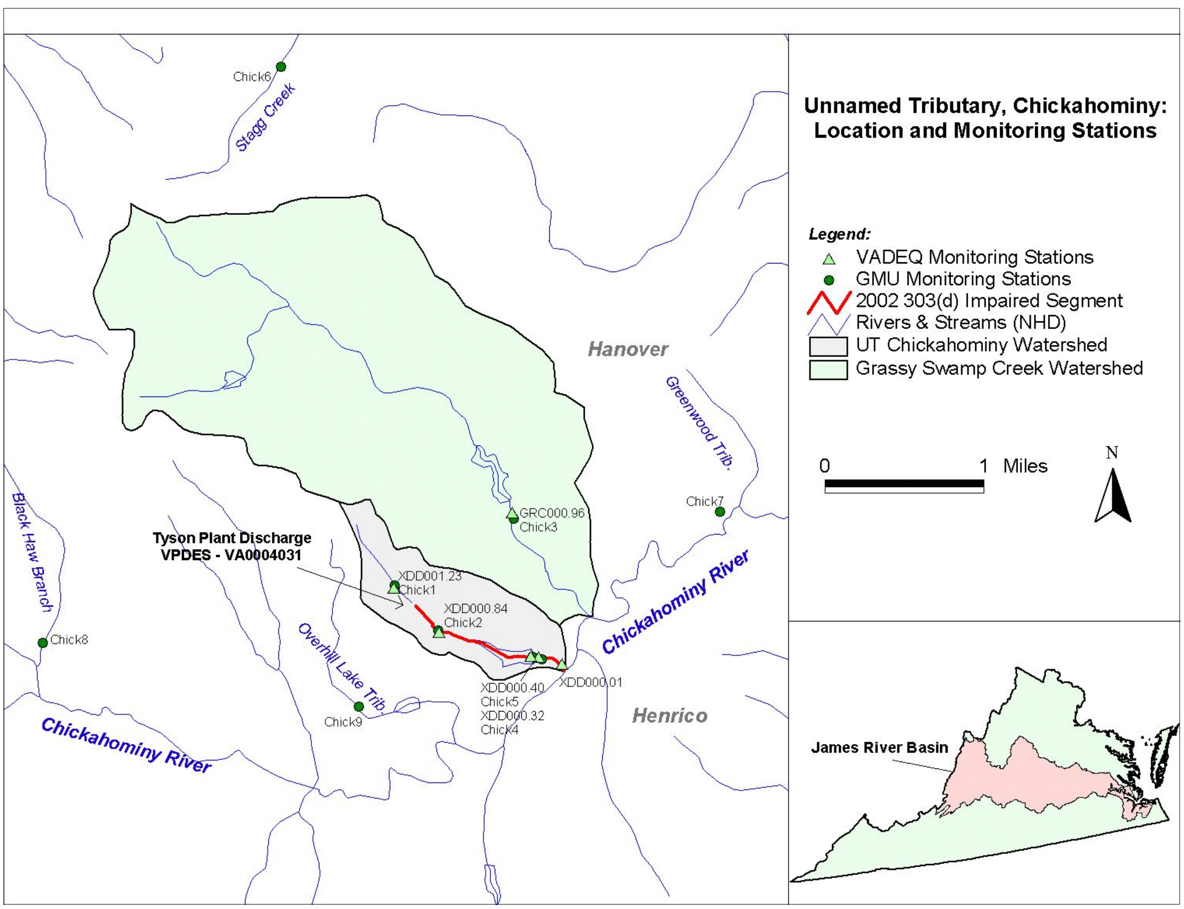

Figure 3.1 Location of UT Chickahominy and reference monitoring stations

3.4 Point Source Discharges

There is one permitted facility located in the UT Chickahominy watershed (Table 3.2). Tyson Foods (VPDES VA0004031) is located in the UT Chickahominy watershed and discharges to the stream 0.3 miles upstream of VADEQ station 2-XDD000.84. The current design flow of the facility is 1.4 MGD. Table 3.3 presents the current permit limits. The flow from this point source discharge accounts for approximately 90% or more of the streamflow in UT Chickahominy.

Table 3.2 VPDES permitted facilities in the UT Chickahominy watershed

VPDES #	Facility	Stream
VA0004031	Tyson Foods Incorporated	UT Chickahominy

Table 3.3 Permit limits for the Tyson Foods discharge permit (VA0004031)

Outfall	Parameter Code	Parameter Description	Conc. Unit	Quantity Unit	Quantity Avg. (monthly)	Quantity Max. (daily)	Conc. Min. (daily)	Conc. Avg. (monthly, except FC)	Conc. Max. (daily)
1	1	FLOW		MGD	NL	NL	*********	*********	*********
	2	PH	SU		*********	*********	6	*********	9
	3	BOD5	MG/L	KG/D	28.4	NL	*********	6	8
	4	TSS	MG/L	KG/D	23.7	NL	*********	5	7.5
	6	COLIFORM, FECAL	N/CML		*********	*********	*********	200 (Geo Mean)	NL
	7	DO	MG/L		*********	*********	5	*********	*********
	12	PHOSPHORUS, TOTAL (AS P)	MG/L	KG/D	1.4	2.4	*********	0.3	0.5
	13	NITROGEN, TOTAL AS N	MG/L	KG/D	NL	NL	*********	NL	NL
	39	AMMONIA, AS N	MG/L	KG/D	9.5	NL	*********	2	NL
	71	SETTLEABLE SOLIDS	ML/L		*********	*********	*********	0.1	NL
	165	CL2, INST RES MAX	PPB		*********	*********	*********	7.97	16.09
	500	OIL & GREASE	MG/L	KG/D	47.3	71	*********	10	15
2	1	FLOW		MG	NL	NL	*********	*********	*********
	2	PH	SU		*********	*********	NL	*********	NL
	3	BOD5	MG/L		*********	*********	*********	*********	NL
	4	TSS	MG/L		*********	*********	*********	*********	NL
	6	COLIFORM, FECAL	N/CML		*********	*********	*********	*********	NL
	12	PHOSPHORUS, TOTAL (AS P)	MG/L		*********	*********	*********	*********	NL
	39	AMMONIA, AS N	MG/L		*********	*********	*********	*********	NL
	68	TKN (N-KJEL)	MG/L		*********	*********	*********	*********	NL
	500	OIL & GREASE	MG/L		*********	*********	*********	*********	NL

CODES: NL = No Limit

Additional discharge information listed in the VADEQ Point Source Data Sheet for VA0004031 is shown in the Table 3.4 Permitted flow is listed as "N/A" and the permit expiration date is 12/2/04.

Table 3.4 Flow and load data (taken from VADEQ Fact Sheet)

	FLOW	TN Conc.	TN LOAD[1]	TP Conc.	TP LOAD[1]
1985	0.59	73.76	132,500	0.08	100
2002	0.91	11.66	32,600	0.25	700
% CHANGE	+54%		-75%		6

Comments: [1]Load value estimates have been rounded to the nearest one hundred pounds.
Receiving stream: Unnamed tributary to Chickahominy River
Limits: Ammonia = 2.0 mg/l (mo. avg.); TP = 0.3 mg/l (mo. avg.) TN = monitoring only; voluntary monitoring of nitrate & nitrite

Discharge Monitoring Report (DMR) data from April 10, 1999 through June 10, 2003 were compared to current permit limits. These data are shown in Figures 3.2 through 3.4. Exceedances were noted for TSS and Residual Chlorine. Tyson Foods Inc. consistently meets VPDES permit requirements and discharges pollutant levels at or below current permit limits.

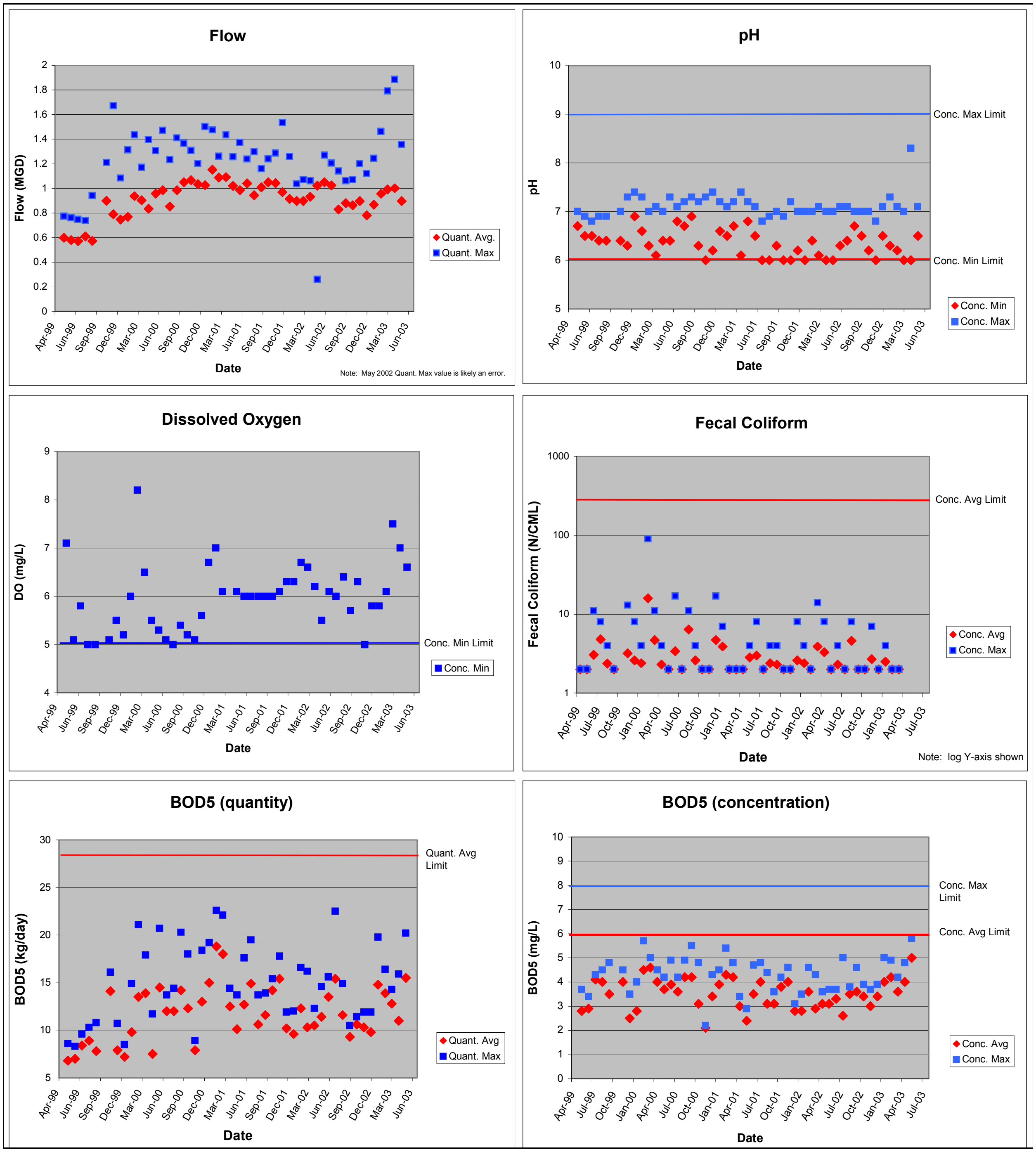

Figure 3.2 DMR data for VA0004031: flow, pH, DO, fecal coliform, BOD5

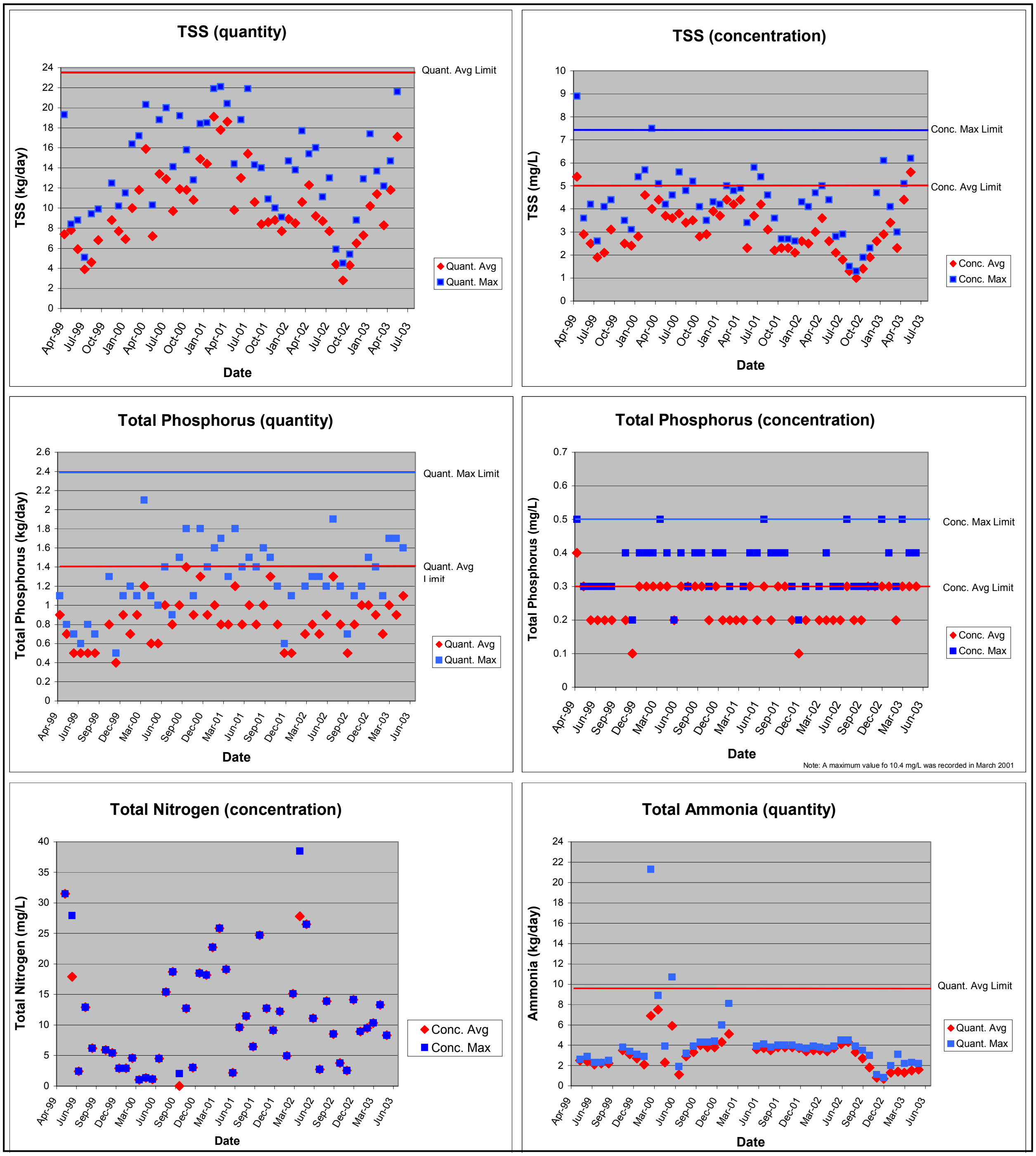

Figure 3.3 DMR data for VA0004031: TSS, TP, TN, ammonia (quantity)

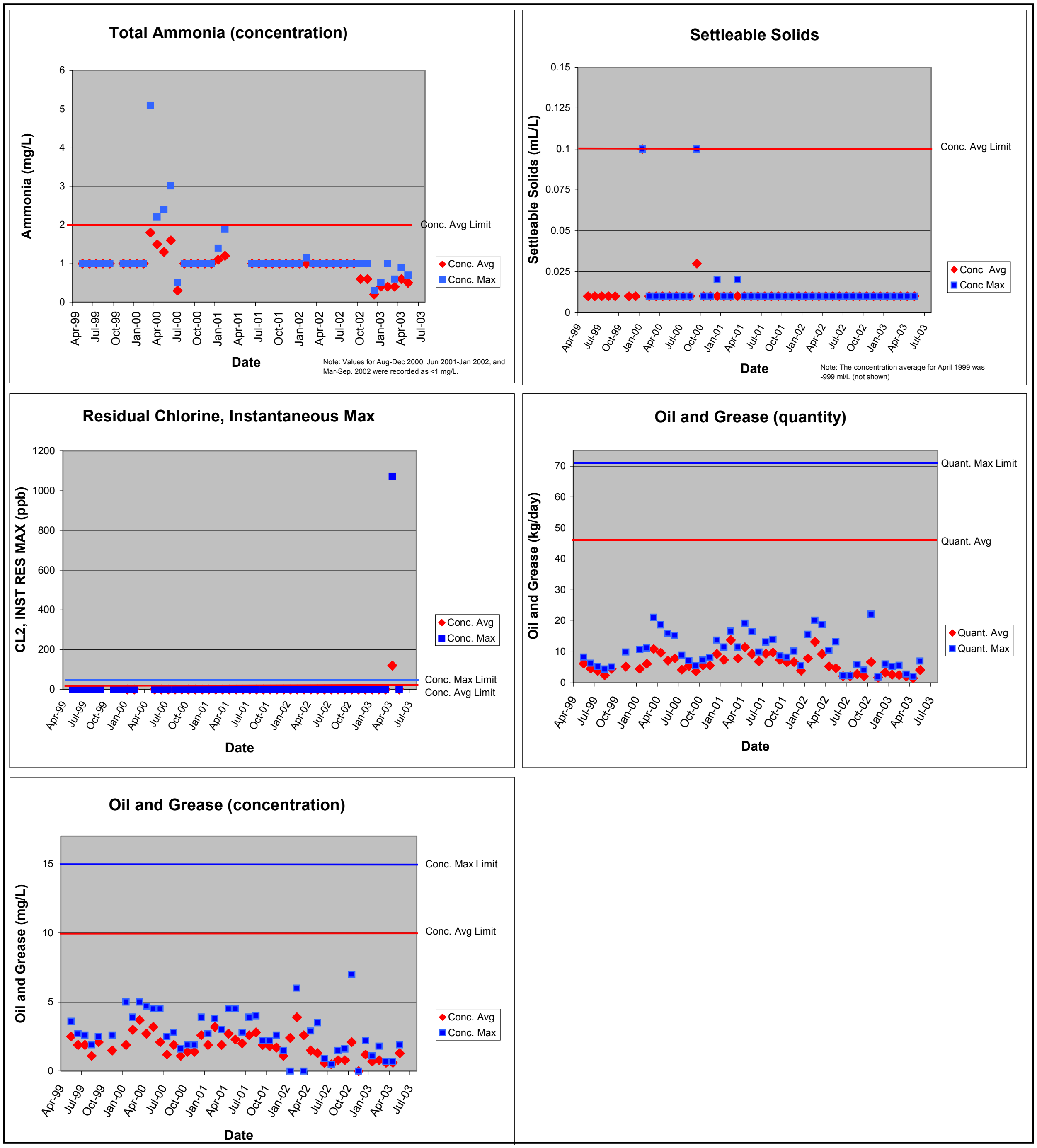

Figure 3.4 DMR data for VA0004031: ammonia (conc.), settleable solids, residual chlorine, oil and grease

3.5 Stressor Analysis Summary

UT Chickahominy stream conditions and impairment causes were characterized using all available water quality, biomonitoring, and habitat data. Selected parameters were plotted to examine spatial trends and to compare to reference stream conditions (Figures 3.5 through 3.34). Water quality monitoring data were analyzed using box-whisker plots and time-series observation plots presented in this section. Median values are shown along with the maximum and minimum values for the period of record. These data are discussed in the report sections following the water quality figures.

*Note that GMU water quality data were added to the VADEQ data set for each station because of the approximate co-location of VADEQ and GMU monitoring stations on both streams. Stations are identified using VADEQ station codes. Time-series plots show the individual observations for all VADEQ and GMU data. Recent VADEQ and GMU water quality data (collected in November and December) are not included in the summary plots. These data are presented in Table 3.7 (GMU data) and Appendix A (VADEQ data).

3.5.1 Water Temperature - Eliminated Stressor

Surface water temperature data for all monitoring stations are shown in Figures 3.5, 3.6, Table 3.7, and Appendix A. The majority of observations were below the Class III maximum criteria (32^{o} Celsius). The highest values were recorded at UT Chickahominy pond station (XDD000.40). Higher temperatures are expected in the pond due to lotic conditions (slower water movement) and the lack of shading. Of the UT Chickahominy stream stations, the highest median and 75th percentile temperature values were recorded at stations XDD000.84 and XDD000.32.

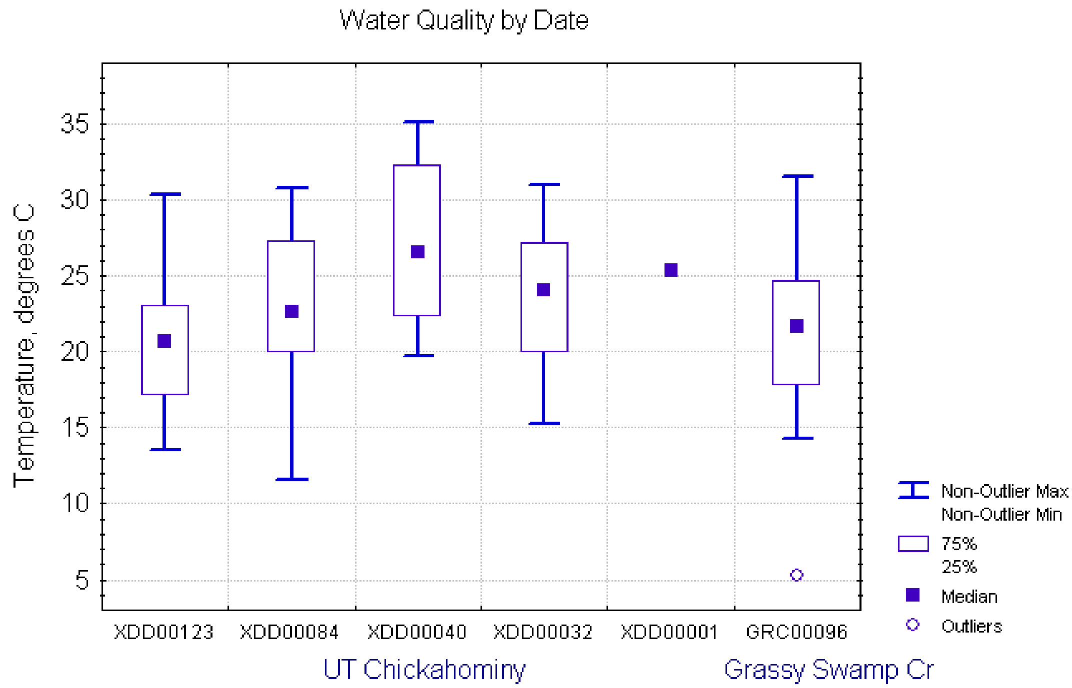

Figure 3.5 Temperature values for UT Chickahominy and Grassy Swamp Creek stations

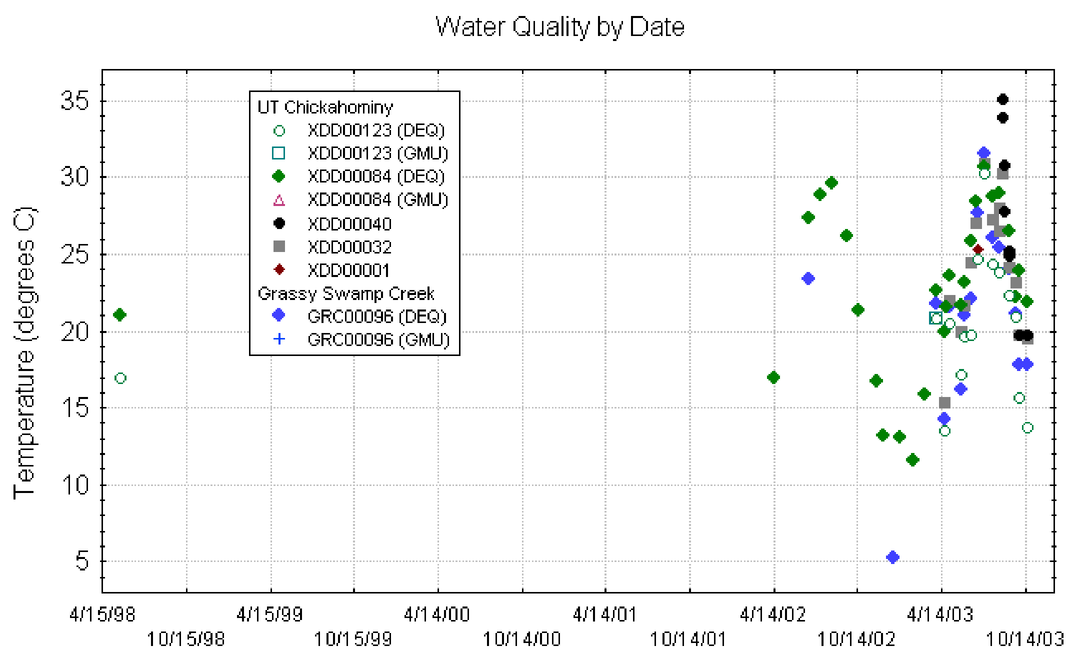

Figure 3.6 Time-series temperature values for UT Chickahominy and Grassy Swamp Creek stations

3.5.2 pH - Most Probable Stressor (downstream)

pH data for UT Chickahominy and Grassy Swamp Creek are shown in Figures 3.7 and 3.8, Table 3.7, and Appendix A. pH values below the minimum standard for Class III waters (6.0 standard units) were recorded at stations XDD001.23 and GRC000.96. Grassy Swamp Creek and the upper portion of UT Chickahominy are tannic and have ponds located just upstream (greater plant decomposition), which can explain the low pH values. pH values recorded at XDD000.40 and XDD000.32 exceed the maximum criteria for Class III waters (9.0 standard units). High pH levels can be toxic to aquatic life. High pH levels can also cause secondary effects, including an increase in the amount of unionized ammonia. Algal blooms in the pond at station XDD000.40 are likely responsible for the high pH levels observed at this station and downstream (XDD000.32). The most likely cause of high pH in an aquatic system is excessive algal growth. This is a direct result of photosynthesis: carbon dioxide is removed from the water column consequently removing carbonic acid (Murphy et al. 2003). The dominant algae was identified by VADEQ personnel as *Anacystis sp*. (Fall 2003).

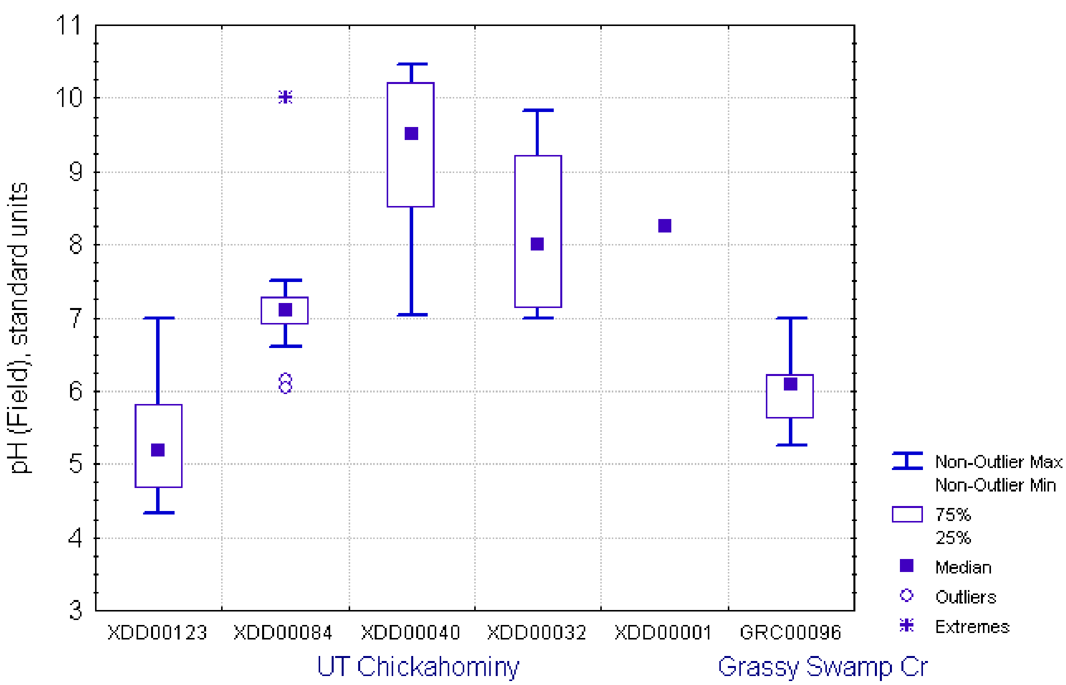

Figure 3.7 pH values for UT Chickahominy and Grassy Swamp Creek stations

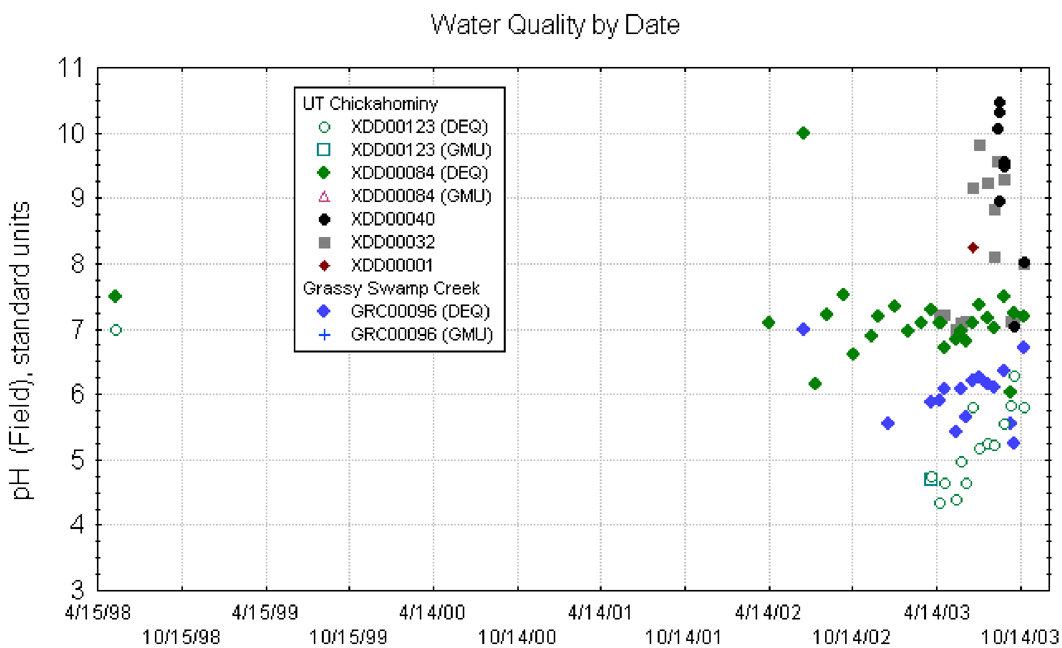

Figure 3.8 Time-series pH values for UT Chickahominy and Grassy Swamp Creek stations

3.5.3 Dissolved Oxygen- Possible Stressor

Dissolved oxygen (DO) criteria established in Virginia's Water Quality Standards represent minimum levels that must be maintained to support aquatic life. Primary producers (algae and macrophytes) produce oxygen during the day through photosynthesis and use oxygen at night through respiration. This diel photosynthesis/respiration cycle results in higher DO concentrations during the day and lower concentrations at night. AWQM DO data collected at stations on UT Chickahominy were compared to the daily average (5.0 mg/L) and minimum (4.0 mg/L) DO criteria listed in Virginia's Water Quality Standards to help determine if DO conditions are considered to be a primary cause of the benthic impairment (Figures 3.9 and 3.10, Table 3.7, and Appendix A). Stations on UT Chickahominy and Grassy Swamp Creek exhibited low DO conditions on several occasions. The lowest median DO values were for XDD001.23 and XDD000.84. The largest range in DO concentrations for the period of record was noted for XDD000.40. The 75th percentile for this station exceeded 20mg/L, which indicates super-saturated conditions likely caused by increased algal activity. The station on Grassy Swamp Creek had one observation below 5 mg/L.

In addition to the ambient data, 24-hour dissolved oxygen monitoring was conducted by VADEQ during the summer of 2003 at two stations on UT Chickahominy (XDD000.32 and XDD000.84) (Figures 3.11 and 3.12). The data collected at XDD000.32, below the pond on UT Chickahominy, displayed a relatively normal diel DO pattern. DO concentrations at this station remained above 6.5

mg/L during this time period. Depressed DO conditions were noted for Station XDD000.84, located 0.3 miles below the Tyson Foods discharge. DO concentrations remained between 5 mg/L and 6.5 mg/L for the majority of the sampling period. The point source discharge from Tyson Foods' essentially regulates the instream DO concentration downstream of the outfall. This relationship is apparent in the diurnal DO data collected by VADEQ in September 2003 at station XDD000.84. The natural day-night fluctuation in DO concentration is muted due to the effect of the effluent discharge, which dominates streamflow. Although the "minimum" DO criteria level was maintained in the stream, these data were characterized as "depressed" because the higher DO levels which are expected during daytime hours did not occur.

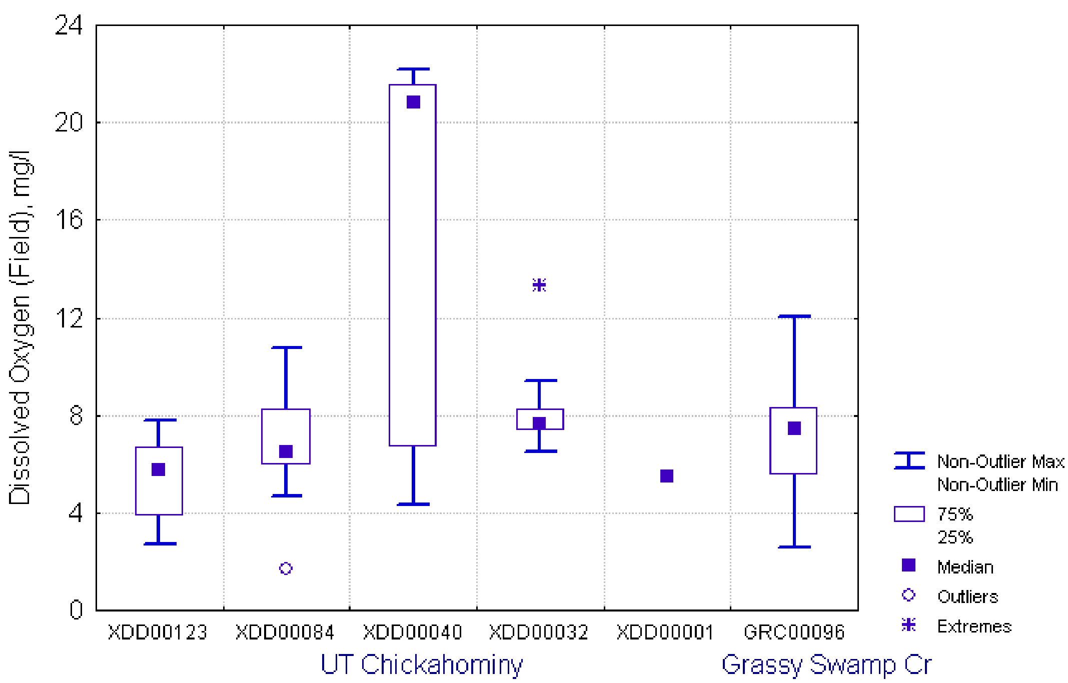

Figure 3.9 DO values for UT Chickahominy and Grassy Swamp Creek stations

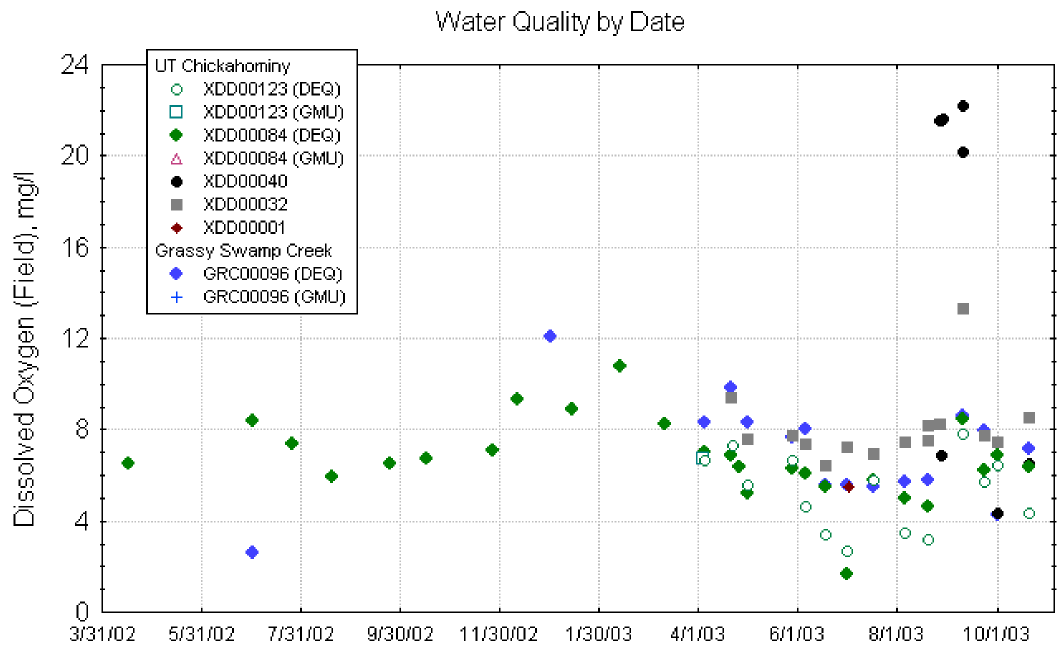

Figure 3.10 Time series DO values for UT Chickahominy and Grassy Swamp Creek stations

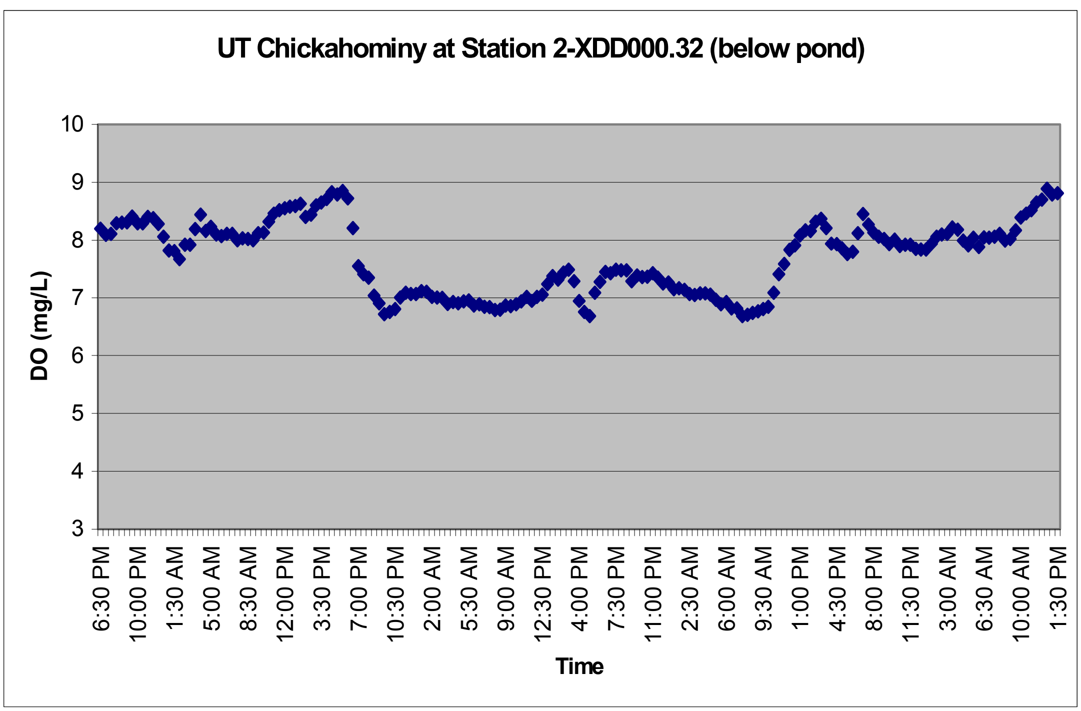

Figure 3.11 Diel DO observations at DEQ Station 2-XDD000.32 (Dates: 8/29/03 - 9/2/03)

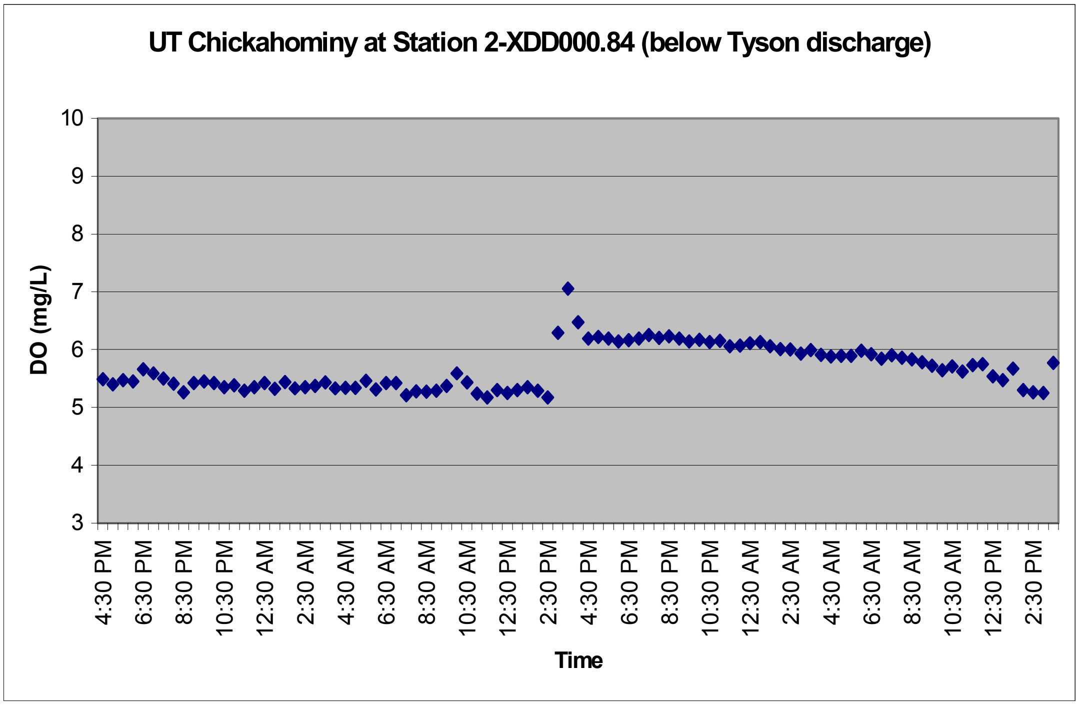

Figure 3.12 Diel DO observations at DEQ Station 2-XDD000.84 (Dates: 9/3/03 - 9/5/03)

3.5.4 Organic Matter - Possible Stressor

BOD5

Biochemical oxygen demand (BOD5) is the measure of the amount of oxygen consumed by microorganisms during decomposition of organic matter. Therefore, this parameter is a good indicator of the amount of organic matter contributed to a waterbody. BOD5 data are presented in Figures 3.13 and 3.14. Station XDD000.84 recorded the highest BOD5 measurements during the data period. All stations with BOD5 data had observations above 3.0 mg/L. BOD5 results at XDD000.84 were above VADEQ Piedmont Regional Office (PRO) ambient background levels (BOD5 >= 5.0 mg/l) in 26% of samples (7 of 23), based on an analysis of 29 background stations located upstream of confined animal feeding operations (CAFOs) in the piedmont region from 1997 -2000 (n=277).

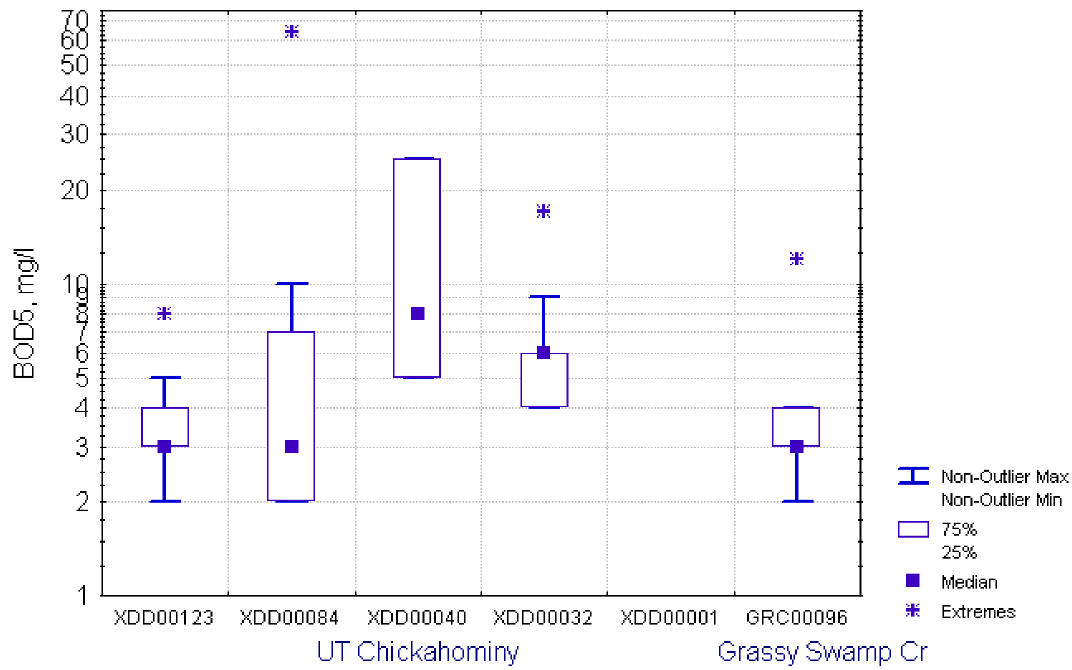

Figure 3.13 BOD5 values for UT Chickahominy and Grassy Swamp Creek stations

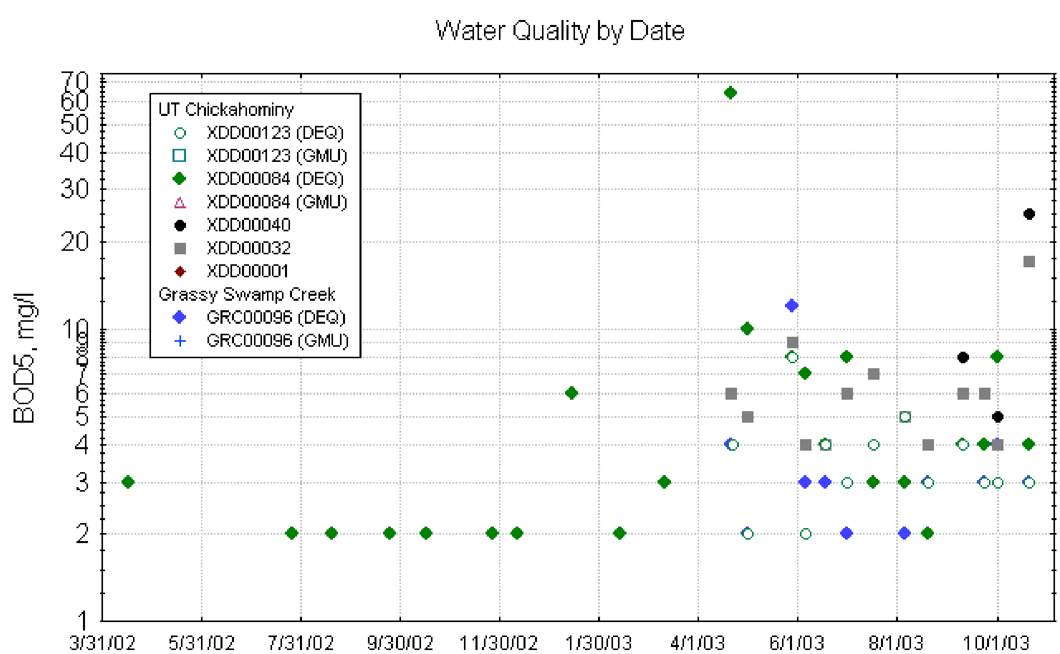

Figure 3.14 Time-series BOD5 values for UT Chickahominy and Grassy Swamp Creek stations

3.5.5 Nutrients - Most Probable Stressor - link to high pH conditions downstream (Chlorophyll a levels also discussed in this section)

Phosphorus

Phosphorus is generally present in waters and wastewaters in different species of soluble (dissolved) and insoluble (particulate or suspended) phosphates, including inorganic (ortho- and condensed) phosphates and organic phosphates. Major sources of phosphorus include detergents, fertilizers, domestic sewage, and agricultural runoff. Total phosphorus and ortho-phosphate data are presented in Figures 3.15 through 3.18, Table 3.7, and Appendix A. Ambient total phosphorus levels are considered high above 0.2 mg/L and very high above 1.0 mg/l. These levels typically cause excessive algal growth, which can adversely impact aquatic life by increasing pH levels as they photosynthesize or bloom, and by lowering DO as they respire and decay. Station XDD000.84 exhibited the highest phosphorus concentrations, on average. TP results at XDD000.84 were above PRO ambient background levels (TP >= 0.37 mg/L) in 54% of samples (13 of 24), based on an analysis of 29 background stations located upstream of confined animal feeding operations (CAFOs) in the Piedmont region from 1997 -2000 (n=277). The majority of the Total Phosphorus observations on Grassy Swamp Creek were at the 0.1 mg/L detection level.

Storm sampling data (Appendix A, Sampled 12/5/03) indicate elevated concentrations below the Tyson effluent outfall (Station XDD001.10) that remain above 0.25 mg/L. Another increase in phosphorus concentration is indicated just below the Tyson stormwater discharge/property line (0.4 mg/L, max. concentration observed). Phosphorus levels lower to approximately 0.3 mg/L from Station XDD000.84 downstream to Station XDD000.69. Station XDD000.65 is located below a wetland/beaver dam area and the concentration at this station is < 0.15 mg/L.

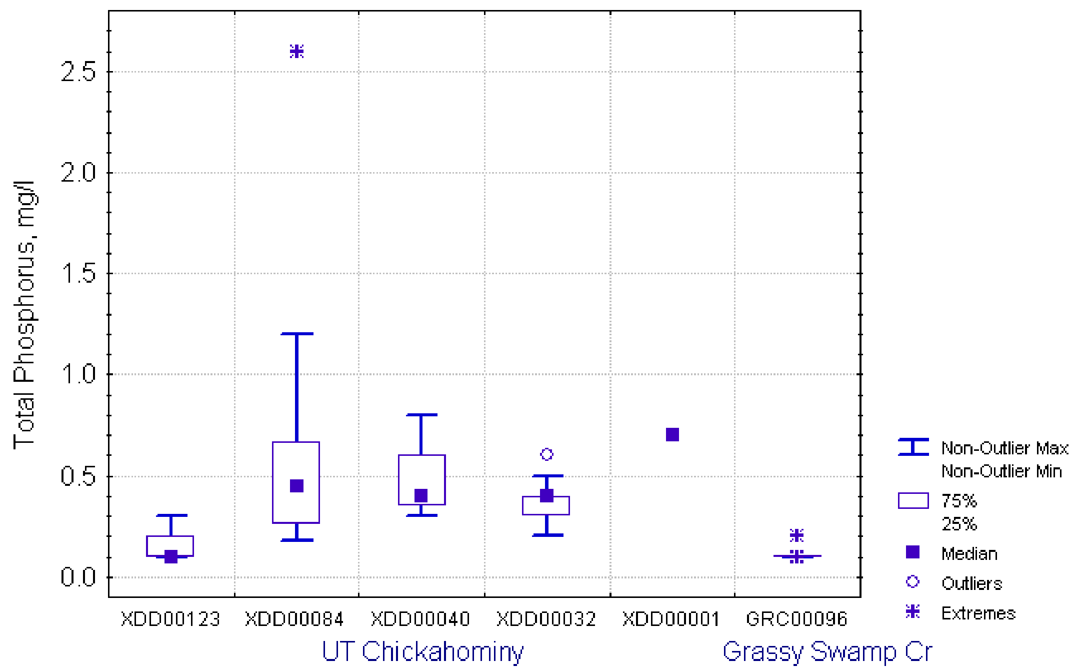

Figure 3.15 Total phosphorus values for UT Chickahominy and Grassy Swamp Creek stations

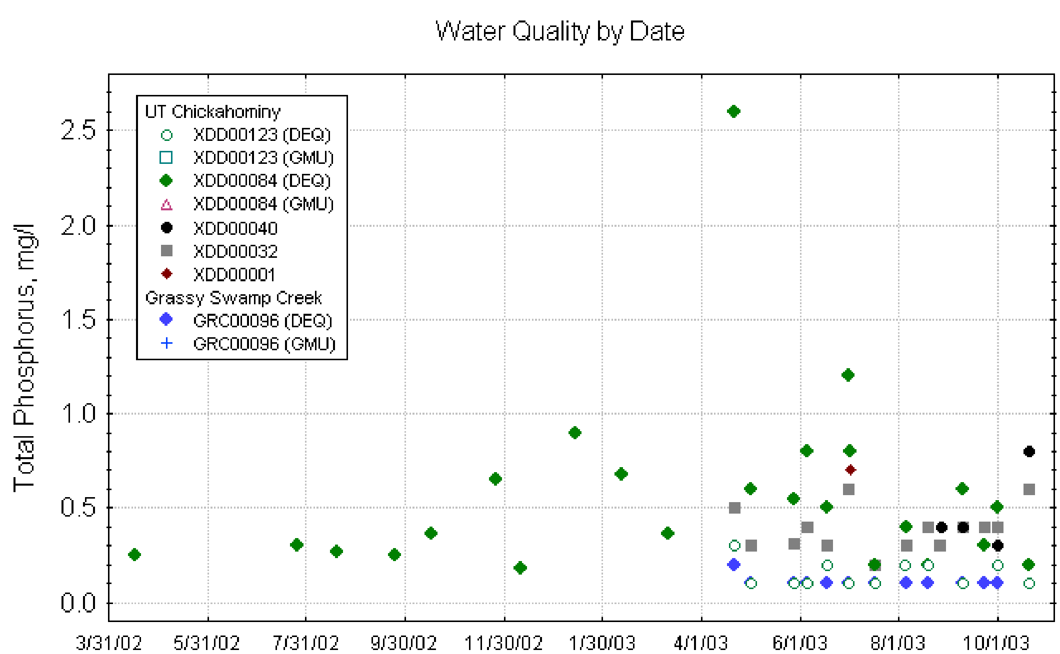

Figure 3.16 Time-series total phosphorus values for UT Chickahominy and Grassy Swamp Creek stations

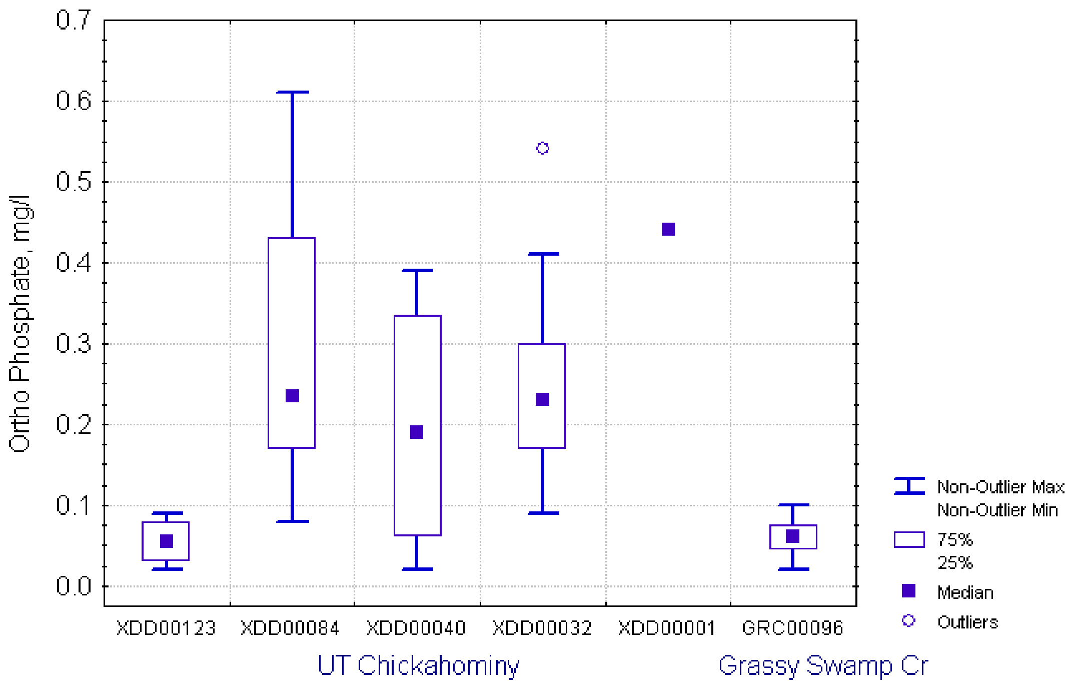

Figure 3.17 Ortho-phosphate values for UT Chickahominy and Grassy Swamp Creek stations

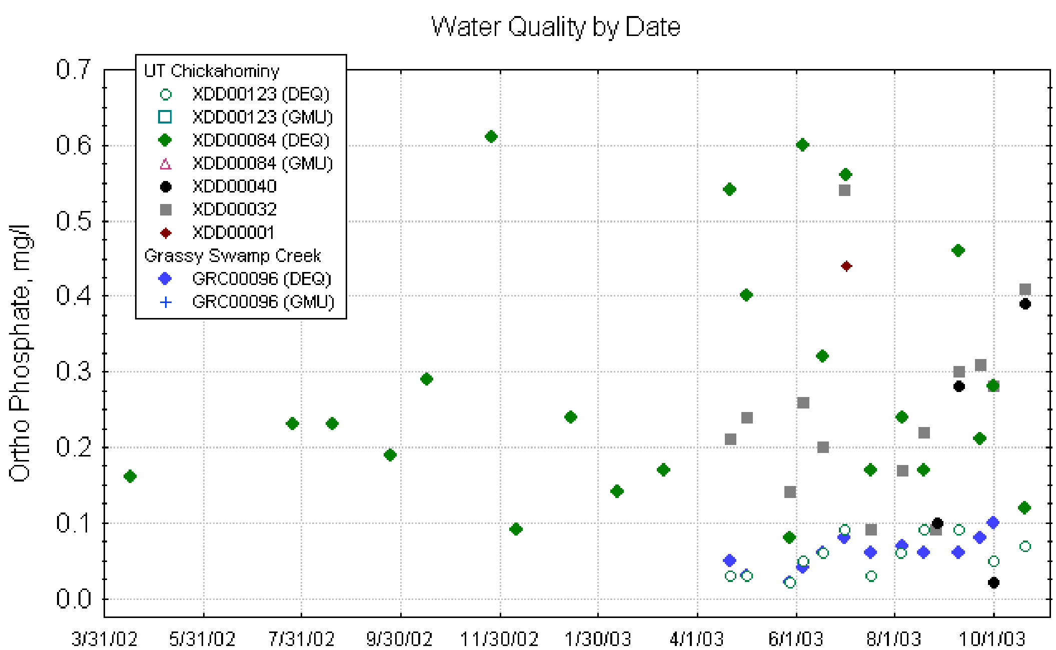

Figure 3.18 Time-series ortho-phosphate values for UT Chickahominy and Grassy Swamp Creek stations

Nitrogen

Major sources of nitrogen include municipal and industrial wastewater, septic tanks, feed lot discharges, animal wastes, runoff from fertilized agricultural fields and lawns, and discharges from car exhausts. Nitrate and Nitrite data are presented in Figures 3.19 through 3.22, Table 3.7, and Appendix A. Nitrite+Nitrate concentrations were recorded for several stations on UT Chickahominy and Grassy Swamp Creek. For the ambient data, Station XDD000.84 had the highest Nitrite+Nitrate concentrations, with GRC000.96 and XDD001.23 having the lowest concentrations (Figures 3.23 and 3.24). Storm sampling nitrogen data (Appendix A, Sampled 12/5/03) shows a similar pattern to the phosphorus data.

TKN and Total Ammonia data are presented in Figures 3.25 through 3.28, Table 3.7, and Appendix A. These data show a similar pattern in the ambient data with the highest concentrations recorded at Station XDD000.84 and the lowest concentrations recorded at GRC000.96. Station XDD001.23 also had low TKN and Total Ammonia concentrations on average. Storm sampling data show the highest concentration at XDD001.15, which is located just below the goose pond/Tyson parking lot (Appendix A). Ammonia concentrations generally increase from <0.4 mg/L at Station XDD001.10 (just below Tyson effluent discharge) to >0.5 mg/L at Station XDD000.69. The lowest concentration was recorded at Station XDD000.65 (located below the wetland/beaver dam). Ammonia results at XDD000.84 were above PRO ambient background levels (>= 0.49 mg/L) in 42% of samples (10 of 24), based on an analysis of 29 background stations located upstream of confined animal feeding operations (CAFOs) in the piedmont region from 1997 -2000 (n=277). Ammonia is also discussed in Section 3.5.7 (Toxic Pollutants).

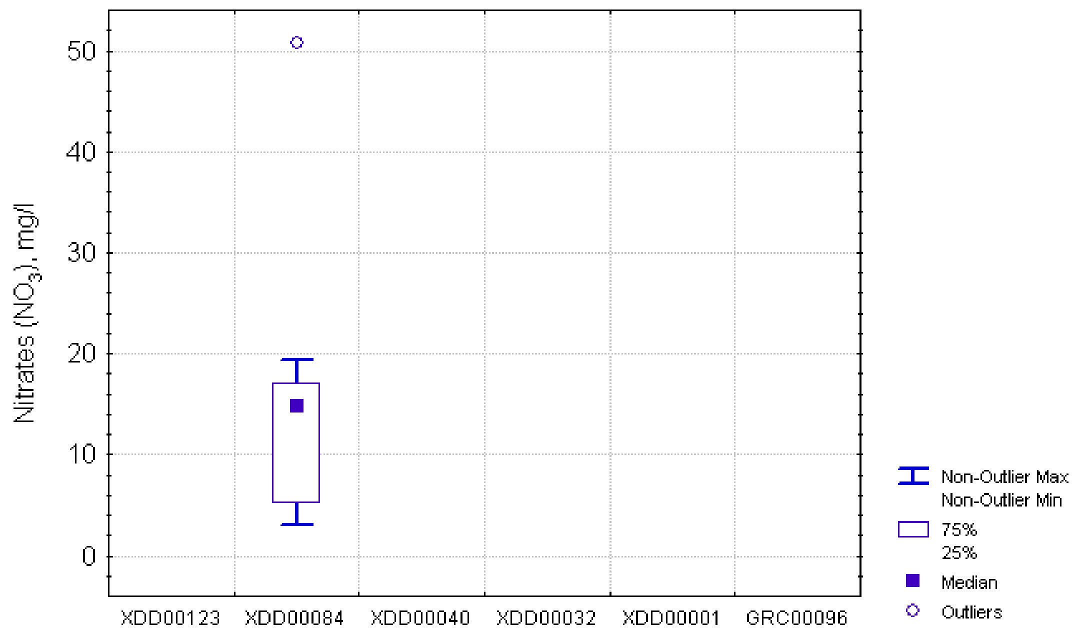

Figure 3.19 Nitrate values for UT Chickahominy and Grassy Swamp Creek stations

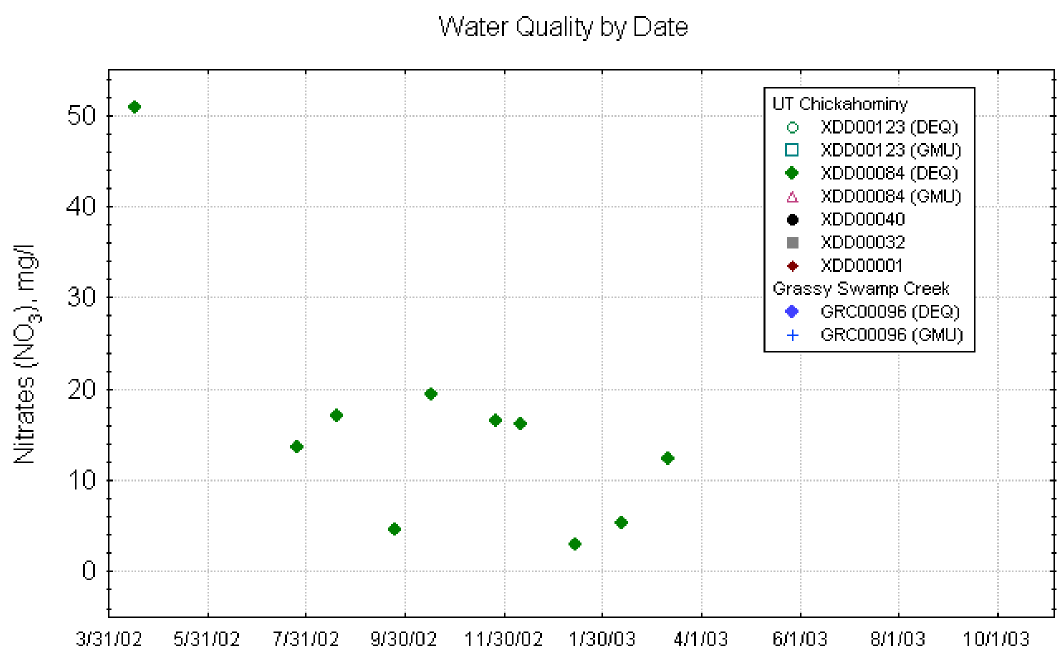

Figure 3.20 Time-series nitrate values for UT Chickahominy and Grassy Swamp Creek stations

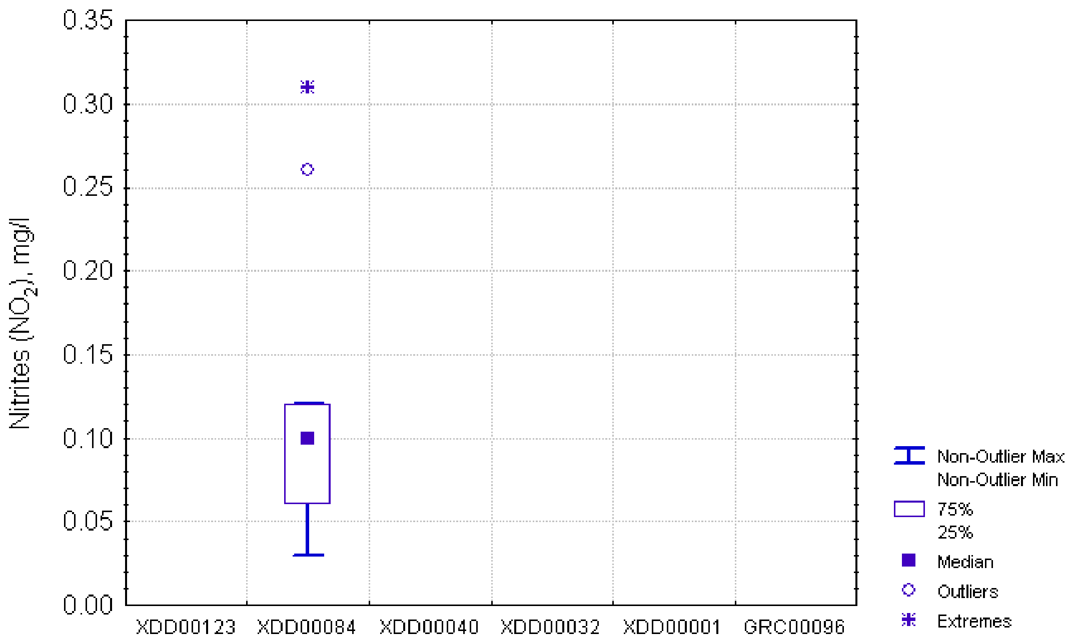

Figure 3.21 Nitrite values for UT Chickahominy and Grassy Swamp Creek stations

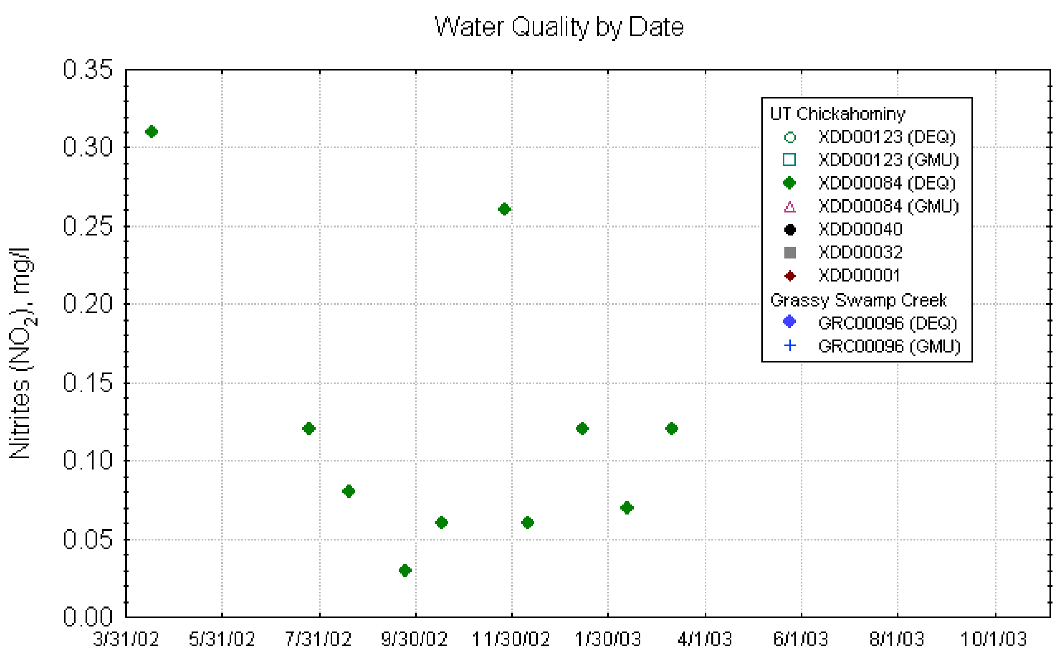

Figure 3.22 Time-series nitrite values for UT Chickahominy and Grassy Swamp Creek stations

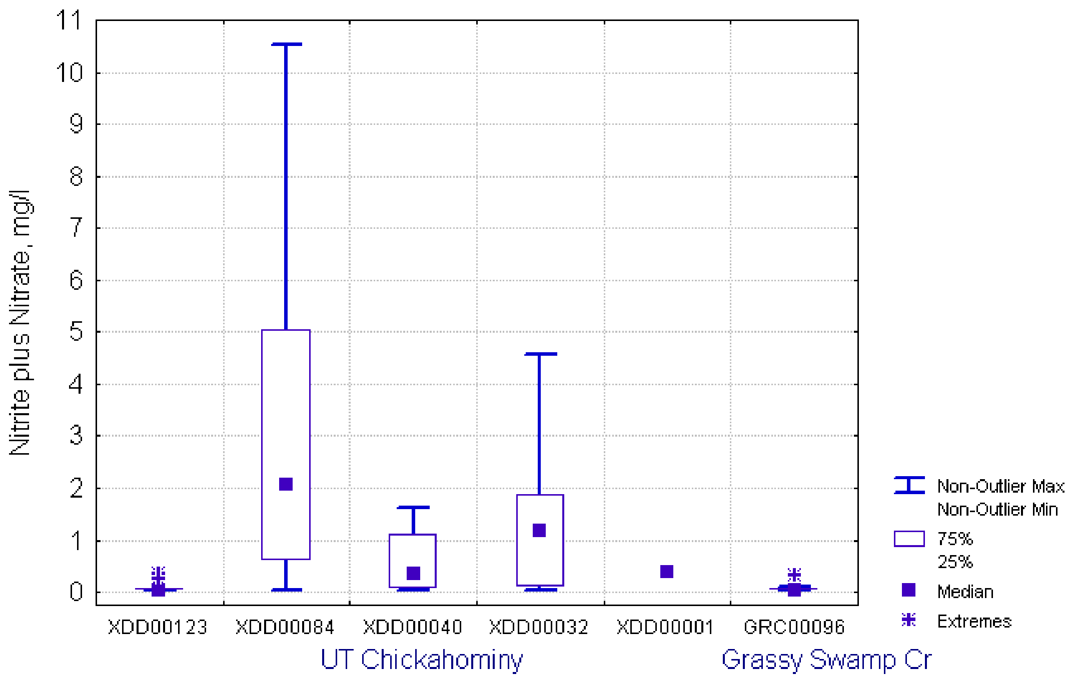

Figure 3.23 Nitrite+nitrate values for UT Chickahominy and Grassy Swamp Creek stations

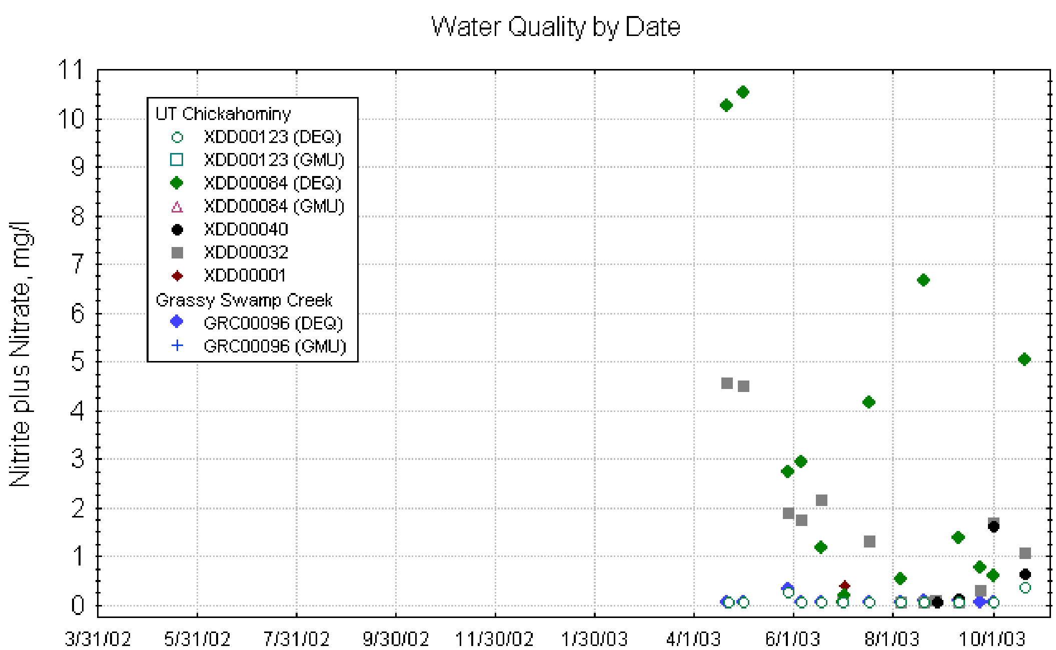

Figure 3.24 Time-series nitrite+nitrate values for UT Chickahominy and Grassy Swamp Creek stations

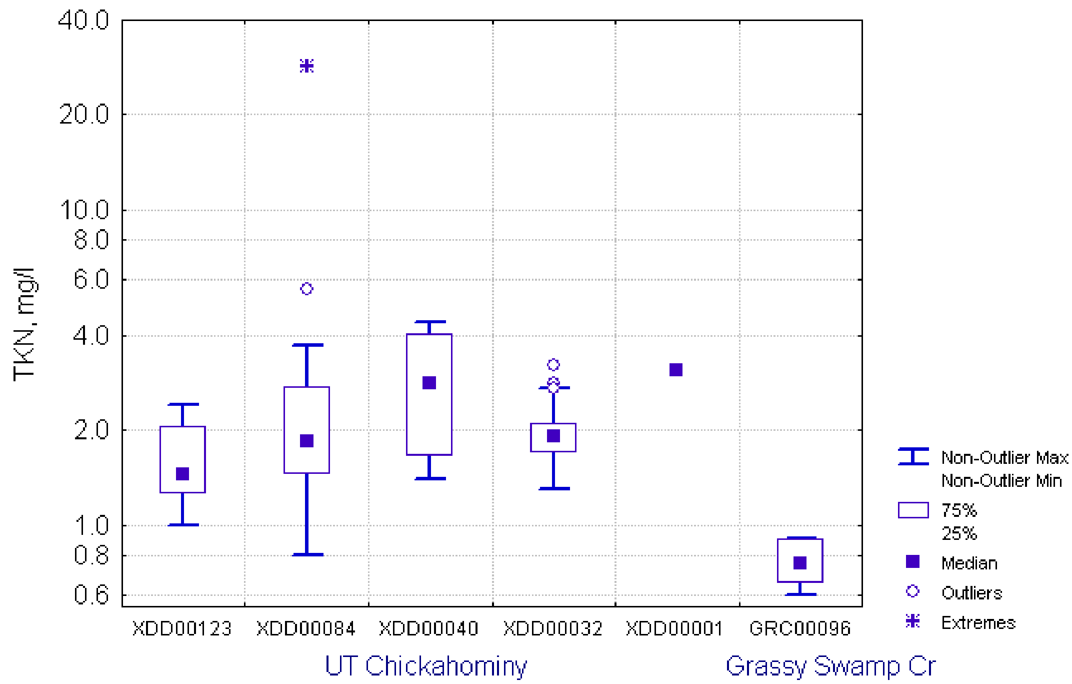

Figure 3.25 TKN values for UT Chickahominy and Grassy Swamp Creek stations

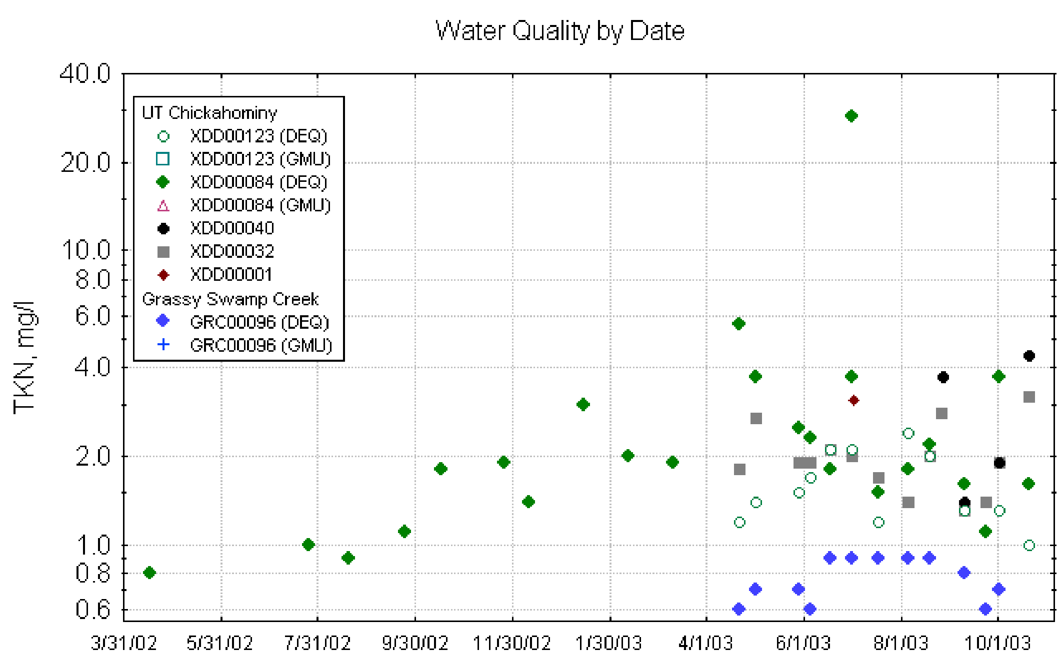

Figure 3.26 Time-series TKN values for UT Chickahominy and Grassy Swamp Creek stations

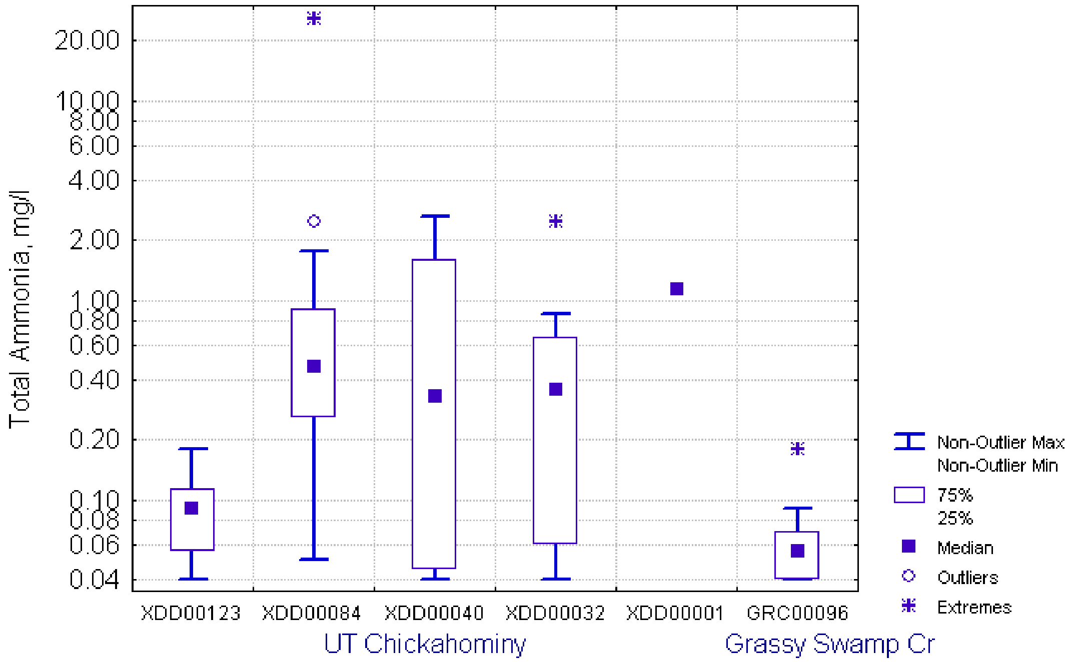

Figure 3.27 Total ammonia values for UT Chickahominy and Grassy Swamp Creek stations

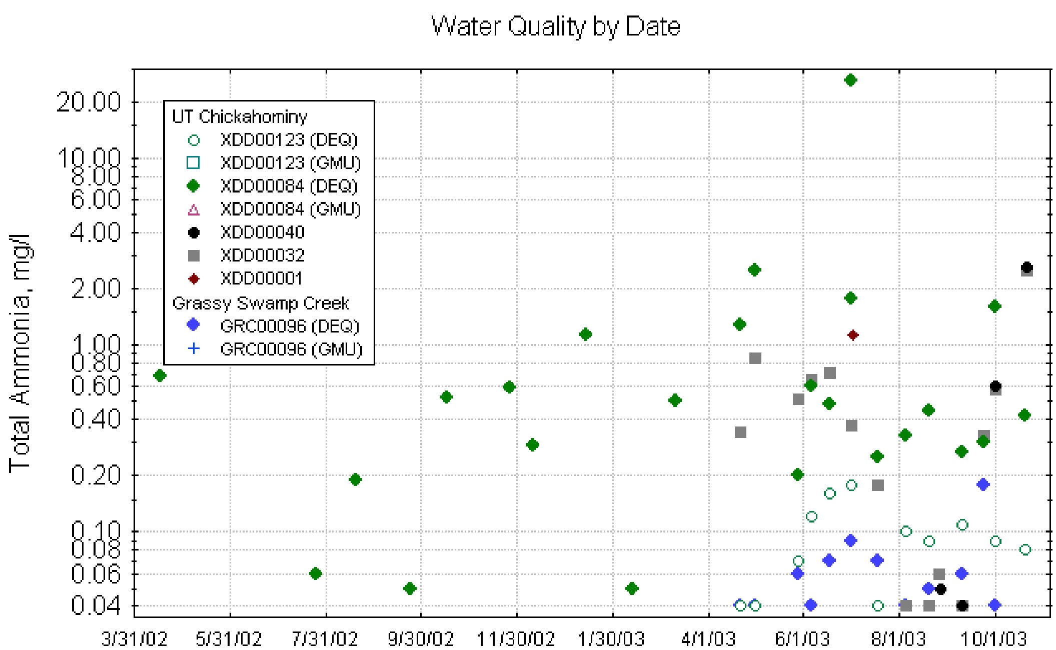

Figure 3.28 Time-series total ammonia values for UT Chickahominy and Grassy Swamp Creek stations

Nitrogen-Phosphorus Ratios

Nitrogen to phosphorus ratios were calculated using available nutrient data for each monitoring station to determine the limiting nutrient in UT Chickahominy. These data are presented in Figures 3.29 and 3.30. UT Chickahominy at station XDD001.23 appears to be phosphorus-limited with the majority of the calculated N:P ratios above 10, which is the threshold generally considered to indicate a phosphorus-limiting condition. N:P ratios indicate nitrogen-limitation at station XDD000.84 and downstream, with the majority of values below 10. The low N:P ratios for the downstream stations were likely due to the excess phosphorus contribution from the point source discharge.

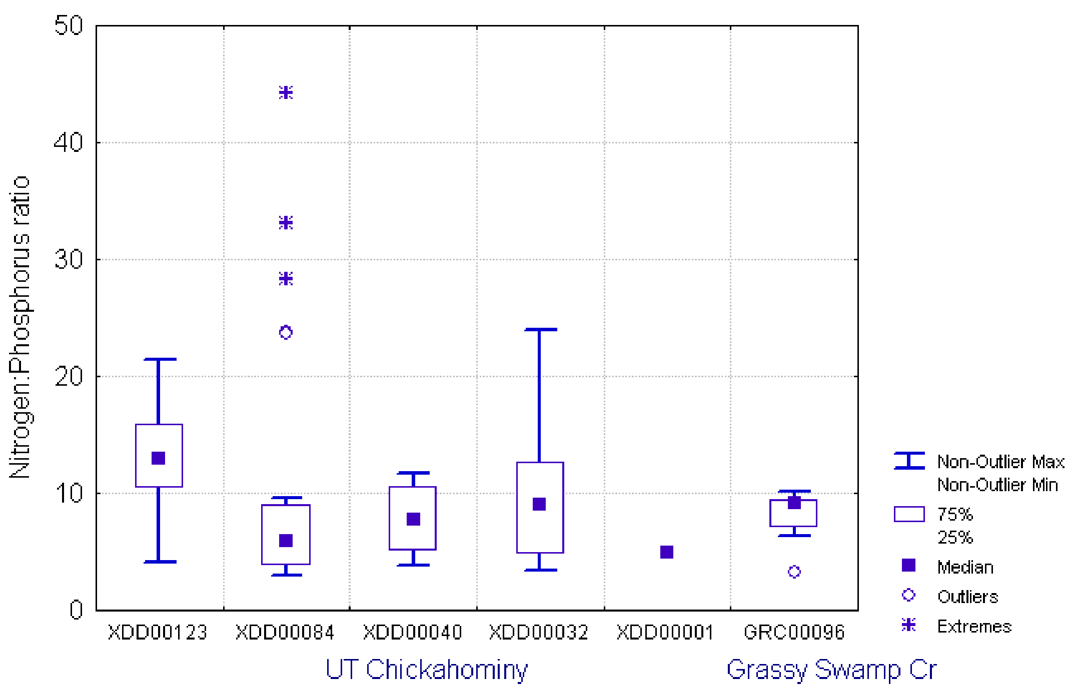

Figure 3.29 N:P ratios for UT Chickahominy and Grassy Swamp Creek stations

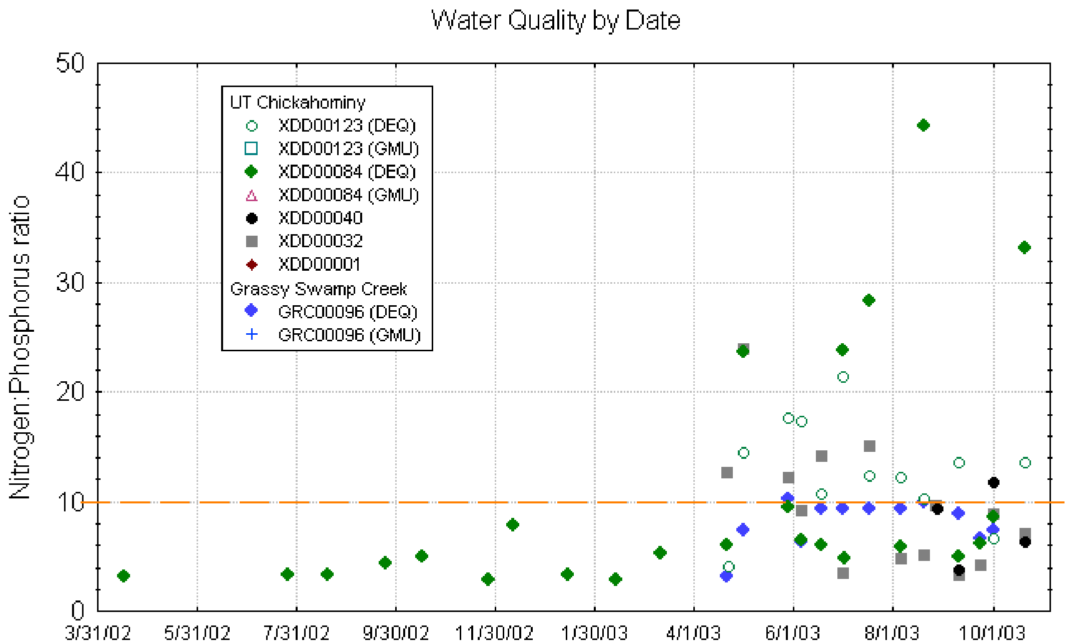

Figure 3.30 Time-series N:P ratios for UT Chickahominy and Grassy Swamp Creek stations

Chlorophyll A

Two stations on UT Chickahominy had Chlorophyll a data (Figures 3.31, 3.32, and Appendix A). All values were greater than the VADEQ 305(b) assessment criteria of 50 mg/kg. As expected, the pond station (XDD000.40) had the highest Chlorophyll a values. The trophic status of the pond is regulated by upstream nutrient inputs from point and nonpoint sources in the watershed. High nutrients over time lead to recurring algal blooms in the pond resulting in high Chlorophyll a levels, high ph levels, and other characteristic eutrophic or hypereutrophic effects. The high Chlorophyll a evidence supports the argument that high photosynthetic rates of algae are leading to the high pH readings noted at stations XDD000.40 and XDD000.32.

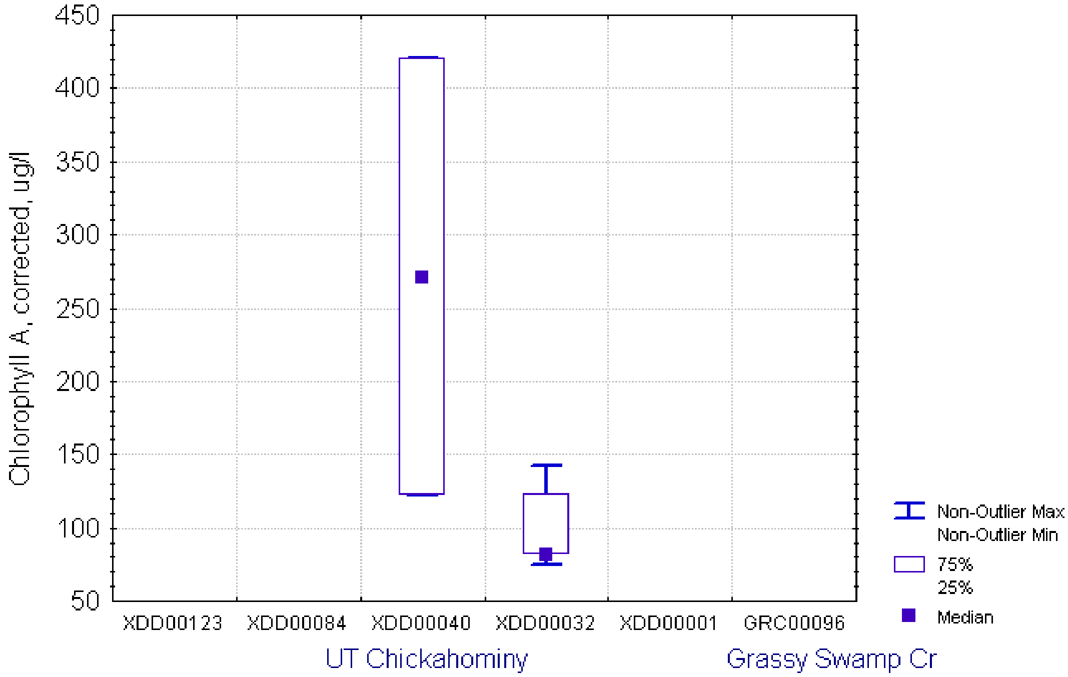

Figure 3.31 Chlorophyll A values for UT Chickahominy and Grassy Swamp Creek stations

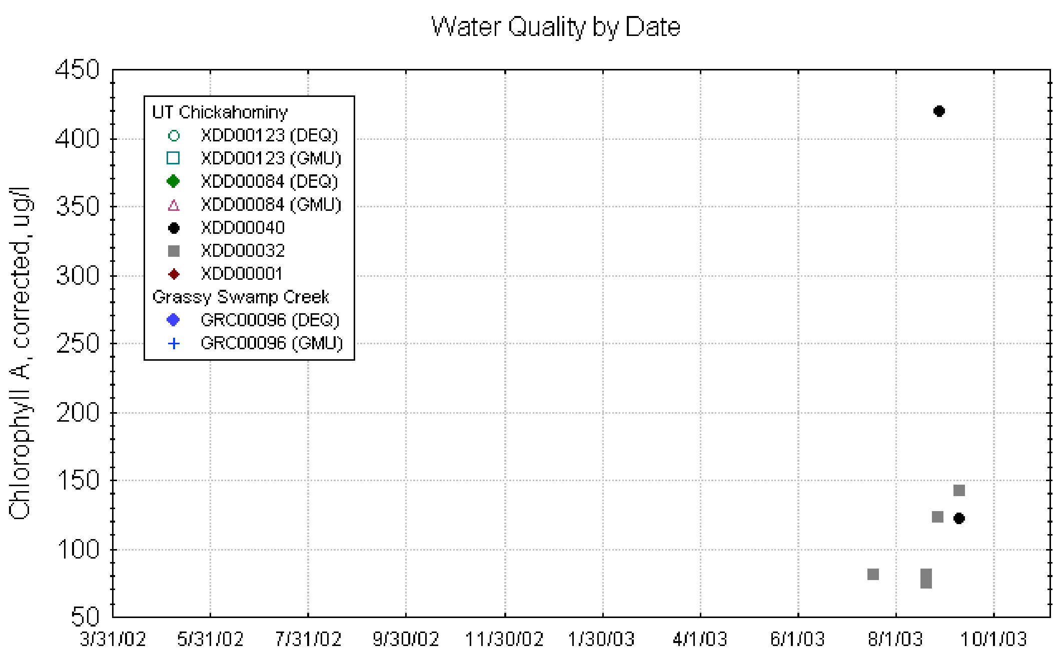

Figure 3.32 Time-series chlorophyll A values for UT Chickahominy and Grassy Swamp Creek stations

3.5.6 Sedimentation/Habitat Alteration - Possible Stressor

Total Suspended Solids

Total Suspended Solids (TSS) data are presented in Figures 3.33 and 3.34, Table 3.7, and Appendix A. Ambient monitoring data indicate higher TSS concentrations in UT Chickahominy as compared to Grassy Swamp Creek. Stations XDD000.40 and XDD000.32 had the highest median, 75th percentile, and non-outlier maximum values.

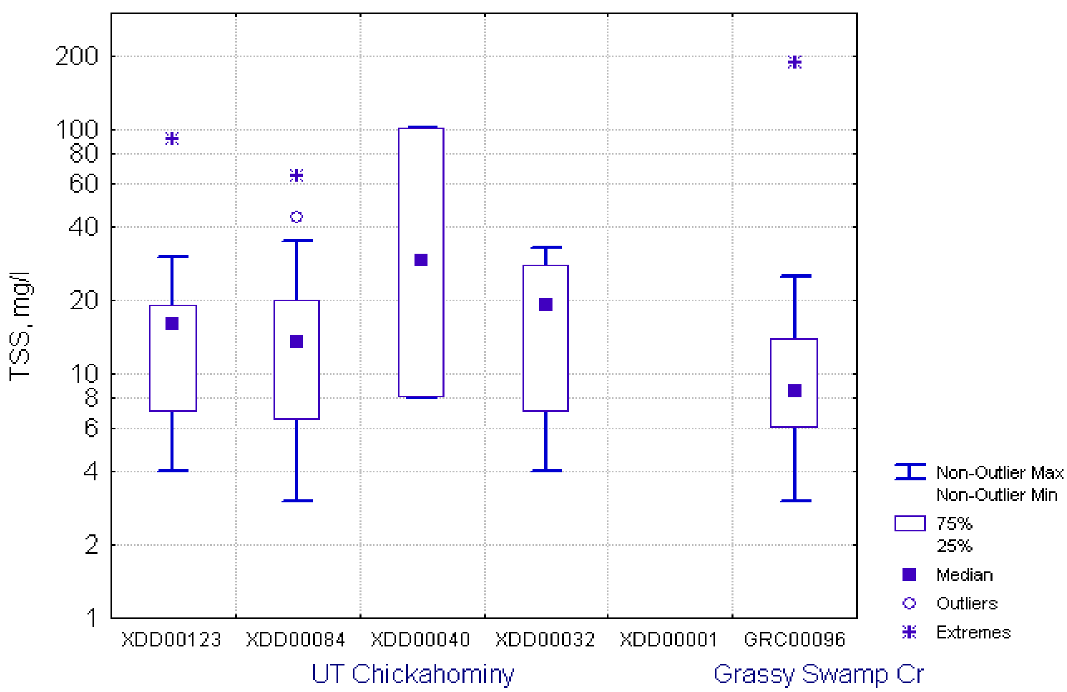

Figure 3.33 Total suspended solids values for UT Chickahominy and Grassy Swamp Creek stations

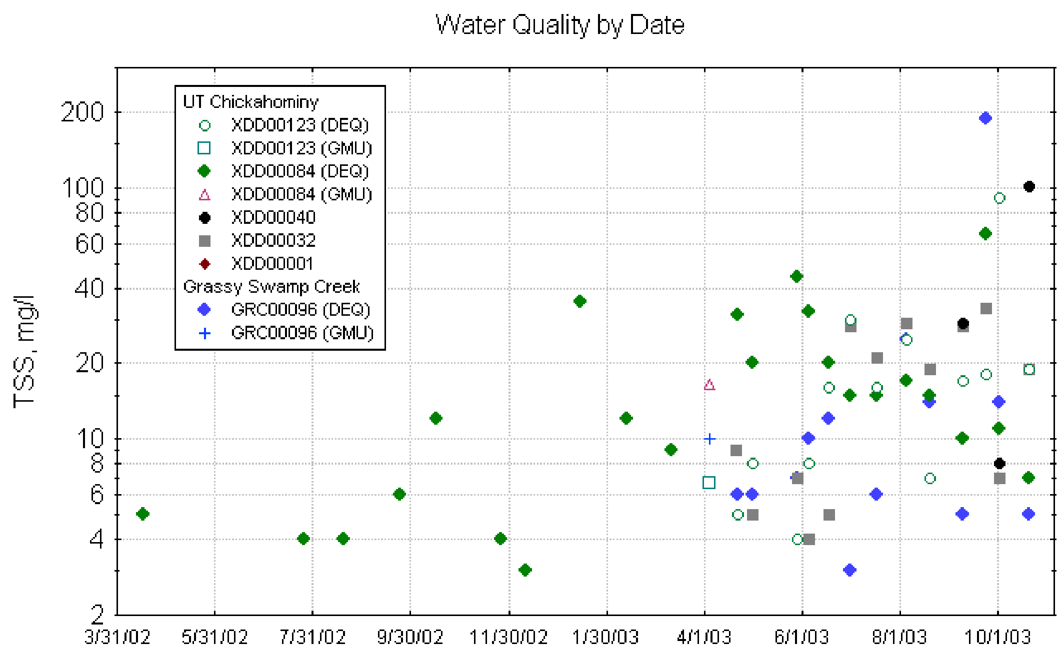

Figure 3.34 Time-series total suspended solids values for UT Chickahominy and Grassy Swamp Creek stations

<u>RBP Habitat Scores</u>

Rapid Bioassessment Protocol (RBP) habitat scores were recorded at biomonitoring stations on UT Chickahominy and Grassy Swamp Creek by VADEQ personnel. All RBP scores were evaluated and rated by observation. These data are summarized in Table 3.5. Overall, Station XDD000.84 had the lowest habitat scores, followed by the upstream station, XDD001.23. Stations XDD000.32 and GRC000.96 had the highest habitat scores indicating better habitat conditions for the benthic community at these sites.

Table 3.5 RBP habitat scores for UT Chickahominy and Grassy Swamp Creek

Station	Date	Total habitat	Bank condition	Bank vegetative protection	Channel alteration	Channel flow status	Embed-dedness/Pool Substrate	Epifaunal substrate	Grazing/ bank disruptive pressure
XDD000.84	11/22/1994	94	7	6	20	7	6	5	8
XDD000.84	05/01/1995	94	7	6	20	7	6	5	8
XDD000.84	05/06/1996	94	7	6	20	7	6	5	8
XDD000.84	10/23/1996	94	7	6	20	7	6	5	8
XDD000.84	05/19/1997	94	7	6	20	7	6	5	8
XDD000.84	11/12/1997	94	7	6	20	7	6	5	8
XDD000.84	05/24/1998	94	7	6	20	7	6	5	8
XDD001.23	11/22/1994	106	12	10	12	4	7	10	9
XDD001.23	05/01/1995	106	12	10	12	4	7	10	9
XDD001.23	05/06/1996	106	12	10	12	4	7	10	9
XDD001.23	10/23/1996	106	12	10	12	4	7	10	9
XDD001.23	05/19/1997	106	12	10	12	4	7	10	9
XDD001.23	11/12/1997	106	12	10	12	4	7	10	9
XDD001.23	05/24/1998	106	12	10	12	4	7	10	9
XDD000.32	07/01/2002	126	12	14	12	9	12*	not measured	not measured
XDD000.32	09/23/2002	126	12	14	12	9	12*	not measured	not measured
GRC000.96	07/01/2002	111	10	10	20	8	7*	not measured	not measured
GRC000.96	09/24/2002	111	10	10	20	8	7*	not measured	not measured

Station	Date	Instream Cover	Riffle frequency / Sinuosity	Riparian vegetation width	Sediment deposition	Velocity-depth regimes / Pool Variability
XDD000.84	11/22/1994	5	5	10	10	5
XDD000.84	05/01/1995	5	5	10	10	5
XDD000.84	05/06/1996	5	5	10	10	5
XDD000.84	10/23/1996	5	5	10	10	5
XDD000.84	05/19/1997	5	5	10	10	5
XDD000.84	11/12/1997	5	5	10	10	5
XDD000.84	05/24/1998	5	5	10	10	5
XDD001.23	11/22/1994	8	2	12	17	3
XDD001.23	05/01/1995	8	2	12	17	3
XDD001.23	05/06/1996	8	2	12	17	3
XDD001.23	10/23/1996	8	2	12	17	3
XDD001.23	05/19/1997	8	2	12	17	3
XDD001.23	11/12/1997	8	2	12	17	3
XDD001.23	05/24/1998	8	2	12	17	3
XDD000.32	07/01/2002	13	8*	20	11	15*
XDD000.32	09/23/2002	13	8*	20	11	15*
GRC000.96	07/01/2002	12	8*	20	8	8*
GRC000.96	09/24/2002	12	8*	20	8	8*

* Note that UT Chickahominy and Grassy Swamp Creek were classified as Low-Gradient streams in 2002.

The following RBP habitat parameters are analagous:

Low Gradient	High Gradient
Pool Substrate	Embeddedness
Pool Variability	Velocity-depth regimes
Sinuosity	Riffle frequency

In November 2003, GMU personnel conducted an assessment of the habitat along UT Chickahominy, as well as other potential reference streams. These habitat scores are shown in Table 3.6. The lowest habitat scores recorded in this assessment were at stations Chick1 and Chick2 on UT Chickahominy, which correspond with VADEQ stations XDD001.23 and XDD000.84, respectively. The highest scores were recorded at Chick4 (which corresponds to VADEQ station XDD000.32) and Chick6, which is located on Stagg Creek.

Table 3.6 GMU RBP habitat scores for UT Chickahominy

StationID	CollDate	Total Habitat Score	Epifaunal substrate/ Available cover	Embed-dedness	Velocity/ Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration
Chick1	11/18/2003	64	8	3	8	6	15	15
Chick2	11/18/2003	67	5	1	7	6	15	16
Chick4	11/17/2003	111	15	6	13	5	17	16
Chick6	11/17/2003	111.5	19	10	13	6	17	15
Chick9	11/18/2003	64.5	9	3	7	3	17	15

StationID	CollDate	Frequency of Riffles	Bank Stability*	Vegetative Protection*	Riparian Vegetative Zone Width*
Chick1	11/18/2003	4	1	3	1
Chick2	11/18/2003	4	4	8	1
Chick4	11/17/2003	16	6	7	10
Chick6	11/17/2003	11	1.5	9	10
Chick9	11/18/2003	2	2	3	3.5

* Note that this is an average of the two scores for left bank and right bank.

3.5.7 Toxics - Possible Stressor

Toxic Pollutants - Surface Water

Virginia's Water Quality Standards list acute and chronic criteria for surface waters (9 VAC 25-260-140). These numeric criteria were developed for metals, pesticides, and other toxic chemicals which can cause acute and chronic toxicity effects on aquatic life and human health. Available water quality data were compared to these criteria to determine possible effects on aquatic life. Ammonia (NH3+NH4) is a critical component of the nitrogen cycle. At high concentrations, ammonia is toxic to aquatic life, depending on pH and temperature levels. In general, the higher the temperature and pH levels, the more toxic ammonia is to aquatic life. Virginia's Water Quality Standards (9 VAC 25-260-155) specify the formulas that are used to calculate the acute and chronic criteria values for ammonia depending on stream type (freshwater or saltwater), temperature, and pH levels, and the expected presence or absence of trout. Ammonia data collected on UT Chickahominy and Grassy Swamp Creek were compared to the calculated acute and chronic criteria using pH and temperature data collected at the same time. An exceedance of the chronic criteria for ammonia (temperature >14.5^{o} Celsius) was recorded at VADEQ station XDD000.01 on July 2, 2003. The total ammonia concentration was 1.13 mg/L and the calculated chronic criterion was 0.83 mg/L. This exceedance occurred following a documented excursion of the ammonia limit in the Tyson discharge permit. The acute and chronic criteria for ammonia are calculated based on ambient water temperature and pH levels. Algal activity in the pond, caused by high nutrient levels and eutrophic conditions, is likely responsible for high pH levels which increase ammonia toxicity. This single ammonia observation is not believed to have caused the observed, persistent low biological community scores.

Virginia's Water Quality Standards (9 VAC 25-260-140) and updated 305(b) assessment guidance include water column criteria and sediment threshold levels for other toxic parameters including metals, pesticides, and organic pollutants. Water quality and sediment data for these parameters were not available for UT Chickahominy stations for the period of record. To help supplement this lack of information, acute and chronic toxicity tests were conducted as discussed below.

EPA Toxicity Tests

A chronic toxicity study was conducted by Environmental Protection Agency using fathead minnows (*Pimephales promelas*) and water flea (*Ceriodaphnia dubia)* (USEPA 2004). The study was conducted on ambient water samples collected from the UT Chickahominy in the Fall of 2003. Water samples were collected below the Tyson Foods discharge at VADEQ station XDD000.84. Test results showed adverse impacts to fathead minnow growth and Ceriodaphnia reproduction as compared to control samples (revised report received from EPA on January 21, 2004). These data indicate potential toxicity problems in the stream that may affect aquatic life.

3.5.8 Additional Water Quality Data

Water quality data collected by GMU personnel in November 2003 are shown in Table 3.7. These data were not included in the previous water quality figures and assessment. These data also show high total phosphorous and nitrate-nitrite readings at UT Chickahominy stations.

Table 3.7 Additional water quality data collected by GMU in November 2003

GMU Station	Stream (DEQ Station)	Temp (deg C)	Cond (umhos)	DO (mg/L)	DO (%)	Lab pH (s.u.)	Alk (mg/L)	TSS (mg/L)	VSS (mg/L)	Nitrate-Nitrogen (mg/L)	Ammonia-Nitrogen (mg/L)	Total Phos (mg/L)
Chick1	UT Chick (XDD001.23)	10.9	62.6	5.8	53.1	5.48	46*	15.3	9.33	1.264	N/A	0.187
Chick2	UT Chick (XDD000.84)	19.5	903	6.8	80.5	7.9	168.1	5.43	N/A	0.960	0.607	0.452
Chick4	UT Chick (XDD000.32)	11.8	622	8.4	78.5	7.69	90	5	4.6	1.717	1.066	0.733
Chick5	UT Chick	12.9	684	6.0	57.8	7.61	89	4.6	4.2	1.483	0.956	0.835
Chick6	Stagg Cr	11.6	19.1	9.8	88.6	7.19	33.5	7.42	4.84	0.608	0.108	0.505
Chick7	Greenwood Trib	12.1	46.1	8.9	82.8	6.97	34	11	6	0.202	N/A	0.080
Chick8	Black Haw Branch	12	44.5	7.0	65.9	6.67	10.95*	15.5	10	0.616	N/A	0.084
Chick9	Overhill Lake Trib	12.7	49.5	5.6	56.9	4.41	5.15*	6	7	1.514	N/A	0.141

*measured with 0.1600 titrant

3.5.9 Review of Benthic Taxa Data and Water Quality Implications

Closer examination of the raw data from the 2003 GMU samples shows a noticeable shift in the biological community below the Tyson Foods discharge (XDD000.84) as well as the station below the impoundment (XDD000.32) compared to the upstream control. The biological community of the upstream control (XDD001.23) consisted of 58% sowbugs and scuds (tiny crustaceans) and 32% aquatic earthworms (segmented worms - no leeches were found) in the April samples, and 75% sowbugs and scuds and 13% aquatic earthworms only in the November samples. The biological community of the segment below the Tyson discharge (XDD000.84) consisted of a single sowbug with an increase to 87% aquatic earthworms and leeches in the April samples and a single sowbug with a similar increase to 71% aquatic earthworms and leeches in the November samples. A similar biological community was also seen in the sample collected at the station below the impoundment farther downstream (XDD000.32) with no sowbugs or scuds and 57% aquatic earthworms and leeches.

Though the biological community at station XDD001.23 is not comprised of what would typically be found in streams considered to have high water quality, it appears to represent a relatively normal community given the stream size and type (a small, 1st order stream with a modest amount of available habitat and flow). The community shift (especially the increase in aquatic earthworms and leeches) seen at stations XDD000.84 and XDD000.32 suggests a change to the water quality below station XDD001.23. A recent inspection of these stations was conducted on February 4, 2004 by Central Office and Piedmont Regional Office staff to gather observational data in order to gain a better understanding of the potential sources that might have an effect on the water quality of UT Chickahominy. Station XDD001.23 was observed to have a channel with "clean" available habitat (i.e., no evidence of growth from periphyton or other biological forms that can cover available in-stream habitat). Station XDD000.32 was observed to have noticeable amounts of this growth as did a stormwater ditch located at the upper part of the truck trailer parking lot that flows into UT Chickahominy just below station XDD001.23 and above the Tyson discharge. At station XDD000.84, while it did contain evidence of such growth on root wads, it was not as noticeable as the aforementioned areas.

While the periphyton evidence suggests that the Tyson discharge is contributing to the nutrient load to the UT Chickahominy, it appears that contributions from NPS runoff within the vicinity of the parking lot are also contributing to the excess nutrients that resulted in the community shift at stations XDD000.84 and XDD000.32. Therefore, a reduction in nutrient loads from these sources should improve water quality to this stream segment. It should be noted that the mere presence of the excess amount of sand and silt deposited on the stream bottom at station XDD000.84 could be viewed as a unique habitat that might be responsible for the increase in the aquatic earthworm population (the amount of sand and silt was very low at station XDD001.23). However, the amount of sand and silt was only slightly more at station XDD000.32 than at XDD001.23, and the available habitat at XDD000.32 was considerably better than stations XDD001.23 and XDD000.84, yet the aquatic earthworm and leech population at station XDD000.32 was still high. This indicates that the response of the biological community below station XDD001.23 is linked not so much to habitat degradation, but rather to nutrient inputs from the point and nonpoint source activities occurring within the Tyson facility and other contributing watershed areas.

3.6 Stressor Conclusions

Water quality and biological conditions in the UT Chickahominy are impacted by several factors, including high pH conditions below the “farm pond” downstream, high nutrient concentrations, poor water quality, habitat alterations and riparian disturbance, and possible unknown toxic effects. High nutrient concentrations contributed by point and nonpoint sources in the watershed have caused excessive algal growth in the downstream pond, resulting in high pH levels and negative impacts to the benthic community. The excessive nutrient enrichment - high pH linkage is considered to be the primary stressor to the benthic community in the lower portion of UT Chickahominy. Habitat degradation caused by the removal of riparian vegetation, possible sedimentation problems, and other factors are believed to be responsible for localized impacts in the upper portion of the watershed.

Nutrient reductions are primarily required to meet the water quality and aquatic life restoration objectives. As a result, a phosphorus TMDL was developed for the UT Chickahominy based on estimates of the relative contribution from point and nonpoint sources in the watershed. Riparian restoration efforts and habitat improvements may also be needed to improve benthic community conditions in upstream areas of the watershed, as detailed in this section. VADEQ will continue to monitor the stream to collect additional information on possible toxic effects and to measure improvements in biological conditions before, during, and after TMDL implementation.

SECTION 4

SOURCE ASSESSMENT - PHOSPHORUS

Point and nonpoint sources of total phosphorus were assessed in TMDL development. The source assessment was used as the basis of model development and analysis of TMDL allocation options. A variety of information was used to characterize sources in the impaired watershed including: MRLC land use/land cover data, water quality monitoring and point source data provided by VADEQ, STATSGO soils data (NRCS), site visit observations, literature sources, and other information. Procedures and assumptions used in estimating nutrient sources in the impaired watershed are described in the following sections. Whenever possible, data development and source characterization were accomplished using locally-derived information.

4.1 Assessment of Nonpoint Sources

Erosion of the land results in the transport of sediment to receiving waters through various processes. Factors that influence erosion include characteristics of the soil, vegetative cover, topography, and climate. Nonpoint sources, such as agricultural land uses and construction areas, are large contributors of sediment because the percentage of vegetative cover is typically lower. Urban areas can also contribute quantities of sediment to surface waters through the build-up and eventual washoff of soil particles, dust, debris, and other accumulated materials. Pervious urban areas, such as lawns and other green spaces contribute sediment in the same fashion as low-intensity pasture areas or other similar land uses. In addition, streambank erosion and scouring processes can result in the transport of additional sediment loads.

Phosphorus, because of its tendency to adsorb to soil particles and organic matter, is primarily transported in surface runoff with eroded sediment. Under normal conditions, phosphorus is scarce in the aquatic environment; however, land disturbance activities and fertilizer applications increase nutrient loading in surface waters. Nonpoint sources of phosphorus include soil erosion, runoff from urban and agricultural lands, animal waste, residential septic systems, and groundwater.

4.1.1 Agricultural Land

Agricultural land was identified as a potential source of nutrients in the UT Chickahominy watershed. Agricultural runoff can contribute increased pollutant loads when farm management practices allow soils rich in nutrients from fertilizers or animal waste to be washed into the stream, increasing in-stream sediment and phosphorus levels. The erosion potential of cropland and over-grazed pasture land is particularly high due to the lack of year-round vegetative cover. The use of cover crops and other management practices have been shown to reduce the transport of pollutant loads from agricultural lands.

The MRLC land use coverage for the UT Chickahominy watershed is shown in Section 3.

4.1.2 Forest Land

Agricultural and urban development in this watershed have replaced some mature forest areas. The nutrient yield from undisturbed forest lands, especially during the growing season, is low due to the amount of dense vegetative cover which stabilizes soils and reduces rainfall impact.

4.1.3 Urban Areas

Urban land uses represented in the MRLC land use coverage include areas classified as commercial, industrial, and transportation areas. The majority of the land area that is categorized as urban is the land occupied by the Tyson Foods processing plant and its parking lot. Urban land uses consist of pervious and impervious areas. Stormwater runoff from impervious areas, such as paved roads and parking lots, contribute pollutants that accumulate on these surfaces directly to receiving waters without being filtered by soil or vegetation. Nutrient deposits in impervious areas originate from vehicle exhaust, industrial and commercial activities, outdoor storage piles, animal waste, and other sources. In addition, stormwater runoff can cause streambank erosion and bottom scouring through high flow volumes, resulting in increased sedimentation and other habitat impacts.

The primary urban sources of nutrients are construction sites and other pervious lands. Construction sites have high erosion rates due to the removal of vegetation and top soil. Fertilizer application on lawns can be a significant source of nutrients and other pollutants. Animal waste is also deposited on pervious urban lands.

Urban land use areas were separated into pervious and impervious fractions based on the estimated percent impervious surface of each urban land use category. Field observations and literature values were used to determine the effective percent imperviousness of urban land uses (Table 4.1).

Table 4.1 Percent imperviousness of urban land uses

Urban land uses	Percent impervious
High Intensity Commercial/Industrial/Transportation	50%

4.1.4 Wildlife

Wildlife has been identified as a potential source of nutrients in the impaired watershed. The nutrient content of wildlife feces can contribute phosphorus to surface waters. The feces are either deposited on the lands and enter the stream with surface runoff, or they are deposited directly into the water. Populations of geese and gulls have been observed in the UT Chickahominy watershed that may contribute to the phosphorus loads. It was estimated that there are approximately 20 geese and 70 gulls that reside in the watershed.

4.2 Assessment of Point Sources

Point sources can contribute nutrient loads to surface waters through effluent discharges. These facilities are permitted through the Virginia Pollutant Discharge Elimination System (VPDES) program that is managed by VADEQ. VPDES individual permits are issued to facilities that must comply with permit conditions that include specific discharge limits and requirements. The Tyson Foods Incorporated processing plant (VPDES VA0004031) is the only point source facility located in the UT Chickahominy watershed. This facility discharges to UT Chickahominy 0.3 miles upstream of the VADEQ biomonitoring station 2-XDD000.84. The current design flow of the facility is 1.4 MGD. Table 4.2 presents the permit limits for the Tyson Foods Incorporated processing plant.

General permits are granted for smaller facilities, such as domestic sewage discharges, that must comply with a standard set of permit conditions, depending on facility type. Currently, there are no VPDES domestic sewage discharge general permits in the impaired watershed.

Table 4.2 Permit limits for the Tyson Foods discharge (VA0004031)

Outfall	Parameter Code	Parameter Description	Conc. Unit	Quantity Unit	Quantity Avg. (monthly)	Quantity Max. (daily)	Conc. Min. (daily)	Conc. Avg. (monthly, except FC)	Conc. Max. (daily)
1	1	FLOW		MGD	NL	NL	*********	*********	*********
	2	PH	SU		*********	*********	6	*********	9
	3	BOD5	MG/L	KG/D	28.4	NL	*********	6	8
	4	TSS	MG/L	KG/D	23.7	NL	*********	5	7.5
	6	COLIFORM, FECAL	N/CML		*********	*********	*********	200 (Geo Mean)	NL
	7	DO	MG/L		*********	*********	5	*********	*********
	12	PHOSPHORUS, TOTAL (AS P)	MG/L	KG/D	1.4	2.4	*********	0.3	0.5
	13	NITROGEN, TOTAL AS N	MG/L	KG/D	NL	NL	*********	NL	NL
	39	AMMONIA, AS N	MG/L	KG/D	9.5	NL	*********	2	NL
	71	SETTLEABLE SOLIDS	ML/L		*********	*********	*********	0.1	NL
	165	CL2, INST RES MAX	PPB		*********	*********	*********	7.97	16.09
	500	OIL & GREASE	MG/L	KG/D	47.3	71	*********	10	15
2	1	FLOW		MG	NL	NL	*********	*********	*********
	2	PH	SU		*********	*********	NL	*********	NL
	3	BOD5	MG/L		*********	*********	*********	*********	NL
	4	TSS	MG/L		*********	*********	*********	*********	NL
	6	COLIFORM, FECAL	N/CML		*********	*********	*********	*********	NL
	12	PHOSPHORUS, TOTAL (AS P)	MG/L		*********	*********	*********	*********	NL
	39	AMMONIA, AS N	MG/L		*********	*********	*********	*********	NL
	68	TKN (N-KJEL)	MG/L		*********	*********	*********	*********	NL
	500	OIL & GREASE	MG/L		*********	*********	*********	*********	NL

CODES: NL = No Limit

SECTION 5

WATERSHED MODELING

5.1 Overall Technical Approach

The impairment listing and stressor analysis identifies excess phosphorus as the primary cause of biological impairment in the UT Chickahominy. The technical approach used to develop TMDLs for the impaired stream was based on identifying the acceptable nutrient (phosphorus) levels that will lead to a reduction in eutrophic conditions in the UT Chickahominy and the downstream pond, specifically. The TMDL endpoint for phosphorus was developed using a model developed by Reckhow (1988) in a study of southeastern lakes and reservoirs. Phosphorus inputs to the model include the nonpoint source load, the point source load, and a load from wildlife.

A watershed model was used to simulate the nutrient loads from potential nonpoint sources in the impaired watershed. The watershed model used in this study was the Generalized Watershed Loading Functions (GWLF) model (Haith and Shoemaker 1987). GWLF modeling was accomplished using the BasinSim 1.0 watershed simulation program, which is a windows-based modeling system that facilitates the development of model input data and provides additional functionality (Dai et al. 2000).

The nutrient loads contributed by wildlife to the impaired watershed were calculated using literature values for phosphorus loads in waterfowl feces (Manny et al. 1975). The nutrient loads from all nonpoint sources, including waterfowl, were then added to the point source load in order to determine the total annual phosphorus load to the UT Chickahominy. Phosphorus TMDLs were then developed for the impaired stream segment based on the calculated endpoint and the results from load allocation scenarios.

5.2 Endpoint Determination

Since eutrophication of the downstream pond ("farm pond") was identified as a stressor in this reach, calculations were performed to determine the maximum nutrient loads which the pond could assimilate and minimize eutrophication and its related problems. A growing season average concentration of 20 ug/L Chlorophyll a was chosen to represent the threshold of eutrophication in the pond (Carlson 1977).

Nutrient ratios suggest that the pond may be somewhat more nitrogen limited than phosphorus limited. However, this analysis focuses on phosphorus for the following reasons:

1. Phosphorus is usually easier to control and, if the ratios are fairly close, the lake will become phosphorus limited as phosphorus is removed.

2. If waterbodies are close to phosphorus limitation they have been shown to follow generally the P loading models such as the one used here.

3. Empirical eutrophication prediction models for P loading are much more well-developed and accepted than models for N loading.

4. The pond is nitrogen limited because the phosphorus concentrations are so high.

The principal model used in this analysis was developed by Reckhow (1988) using a data set of 80 lakes and reservoirs from nine southeastern states including Virginia. This model allows for prediction of ambient total phosphorus concentration in the lake based on phosphorus inputs, hydraulic detention time, and mean depth. Phosphorus inputs include the nonpoint source load, a waterfowl load, and the load from the Tyson Foods plant (based on the permit limit for concentration of phosphorus and design flow). Mean depth was based on field measurements at 12 locations in the pond taken by VADEQ. Hydraulic detention time was the annual water inflow to the pond (Tyson flow plus watershed runoff) divided by the volume of the pond (area times mean depth). Predicted total phosphorus concentration was converted into a value for growing season average Chlorophyll a using the equations of Carlson (1977). Calculations were made using existing loads and then loads were adjusted to find the load that was predicted to result in 20 ug/L Chlorophyll a. This model indicated that annual total P load would need to be reduced from the current 604,193 g/yr (1,332 lbs/yr) to 197,076 g/yr (434 lbs/yr) in order to achieve the 20 ug/L Chlorophyll a target.

The Reckhow model gave similar results to the often used Vollenweider model (Novotny and Olem 1994) at a lower target of 6.7 ug/L Chlorophyll a. It was not possible to test the Reckhow model vs. the Vollenweider model at a target of 20 ug/L because the Vollenweider model examines the relationship between the annual loading of phosphorus per unit lake area and two alternative phosphorus concentrations. Both the Reckhow and Vollenweider models take into account natural attenuation processes like settling that actually decrease the phosphorus concentration as it enters the lake.

5.3 Watershed Model

Nonpoint source loads were estimated using BasinSim 1.0 (GWLF model). The GWLF model, which was originally developed by Cornell University (Haith and Shoemaker 1987, Haith et al. 1992), provides the ability to simulate runoff, sediment, and nutrient loadings from watersheds given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data.

GWLF is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on daily water balance totals that are summed to give monthly values.

GWLF is an aggregate distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. Each area is assumed to be homogenous with respect to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For subsurface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for subsurface flow contributions. Daily water balances are computed for an unsaturated zone as well as for a saturated subsurface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

GWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE) algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss/erosion (K), the length/slope factor (LS), the vegetation cover factor (C), and the conservation practices factor (P). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area. Point source discharges also can contribute to loads to the stream. Evapotranspiration is determined using daily weather data and a cover factor dependent on land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values. All of the equations used by the model can be found in the original GWLF paper (Haith and Shoemaker 1987) and GWLF User's Manual (Haith et al. 1992).

Slight modifications were made to the GWLF model in order to include sediment loads from lands classified as impervious urban areas. The inclusion of these loads is based on nutrient accumulation and washoff functions.

For execution, the model requires three separate input files containing transport, nutrient, and weather-related data. The transport file (TRANSPRT.DAT) defines the necessary parameters for each source area to be considered (e.g., area size, curve number) as well as global parameters (e.g., initial storage, sediment delivery ratio) that apply to all source areas. The nutrient file (NUTRIENT.DAT) specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations). The weather file (WEATHER .DAT) contains daily average temperature and total precipitation values for each year simulated.

5.3.1 Model Setup

Watershed data needed to run the GWLF model in BasinSim 1.0 were generated using GIS spatial coverages, water quality monitoring and streamflow data, local weather data, literature values, and other information. Watershed boundaries for the UT Chickahominy were delineated based on hydrologic and topographic data (USGS 7.5 minute digital topographic maps (24K DRG - Digital Raster Graphics)), and the location of VADEQ monitoring stations. The outlet of the UT Chickahominy watershed is the downstream limit of the stream segment where it confluences with the Chickahominy River.

Local rainfall and temperature data were used to simulate flow conditions in the modeled watershed. Daily precipitation and temperature data were obtained from local National Climatic Data Center (NCDC) weather stations. The weather station that corresponds with the modeled watershed is shown in Table 5.1. The period of record selected for model calibration runs (April 1, 1991 through September 30, 2002) was based on the availability of recent weather data and corresponding streamflow records. The weather data collected at the NCDC station of Richmond International Airport (precipitation and temperature data) were used to construct the weather file used in the watershed simulation.

Table 5.1 Weather station used in GWLF model

Watershed	Weather Station	Data Type	Data Period
UT Chickahominy	Richmond International Airport (7201)	Daily Precipitation, Daily Temperature	4/1/90 - 12/31/02

Daily streamflow data are needed to calibrate watershed hydrologic parameters in the GWLF model. A USGS gage station (02036500) located on Fine Creek at Fine Creek Mills, Virginia was used to calibrate the impaired watershed. Table 5.2 lists the USGS gaging station along with the period of record used for the watershed.

Table 5.2 USGS gaging station used in GWLF model

Modeled Watershed	USGS station number	USGS gage location	Data Period
UT Chickahominy	02036500	Fine Creek at Fine Creek Mills, VA	4/1/90 - 9/30/02

5.3.2 Explanation of Important Model Parameters

In the GWLF model, the nonpoint source load calculation is affected by terrain conditions, such as the amount of agricultural land, land slope, soil erodibility, farming practices used in the area, and by background concentrations of nutrients (nitrogen and phosphorus) in soil and groundwater. Various parameters are included in the model to account for these conditions and practices. Some of the more important parameters are summarized as follows:

Areal extent of different land use/cover categories: The MRLC land use coverage was used to calculate the area of each land use category in the impaired watershed.

Curve number: This parameter determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use/cover and hydrologic soil type and is calculated directly using digital land use and soils coverages. Soils data for the impaired watershed were obtained from the State Soil Geographic (STATSGO) database for Virginia, developed by NRCS.

K factor: This factor relates to inherent soil erodibility, and it affects the amount of soil erosion taking place on a given unit of land. The K factor and other Universal Soils Loss Equation (USLE) parameters were downloaded from the NRCS Natural Resources Inventory (NRI) database (1992). Average values for specific crops/land uses in each watershed county were used (Hanover County). The predominant crop grown in this watershed is corn; therefore, cropland values were based on data collected in corn crops.

LS factor: This factor signifies the steepness and length of slopes in an area and directly affects the amount of soil erosion.

C factor: This factor is related to the amount of vegetative cover in an area. In agricultural areas, this factor is largely controlled by the crops grown and the cultivation practices used. Values range from 0 to 1.0, with larger values indicating a higher potential for erosion.

P factor: This factor is directly related to the conservation practices used in agricultural areas. Values range from 0 to 1.0, with larger values indicating a lower potential for erosion.

Sediment delivery ratio: This parameter specifies the percentage of eroded sediment delivered to surface water and is empirically based on watershed size.

Unsaturated available water-holding capacity: This parameter relates to the amount of water that can be stored in the soil and affects runoff and infiltration.

Other less important factors that can affect sediment loads in a watershed also are included in the model. More detailed information about these parameters and those outlined above can be obtained from the GWLF User's Manual (Haith et al. 1992). Pages 15 through 41 of the manual provide specific details that describe equations and typical parameter values used in the model.

5.3.3 Hydrology Calibration

Using the input files created in the BasinSim 1.0, GWLF predicted overall water balances in the impaired watershed. As discussed in Section 5.3.1, the modeling period is determined based on the availability of weather and flow data that were collected during the same time period. For the impaired watershed (UT Chickahominy) weather data obtained from the NCDC meteorological station located at Richmond International Airport were used to model the watershed. However, the calibration period was governed by the availability of the USGS gaging data. The UT Chickahominy watershed was calibrated for a period of 11.5 years from 4/1991 to 9/2002 using the streamflow gage data from the nearby USGS gage 02036500 on Fine Creek at Fine Creek Mills, Virginia. Although the streamflow gage is in close proximity to the impaired stream, the gage did not coincide with the pour point of the watershed. Hence, the streamflow measurements were normalized by area to facilitate calibration. Calibration statistics are presented in Table 5.3. These results indicate a good correlation between simulated and observed results for the watershed, given the size and characteristics of the watershed. A total flow volume error percentage of approximately 8% was achieved in calibration of the model for the watershed. In general the seasonal trends and peaks are captured reasonably well for the 11.5 year period in the impaired watershed. Hydrology calibration results and the modeled time period for the impaired watershed are given in Table 5.3 and Figure 5.1. Differences between observed and modeled flows in this watershed are likely due to inherent errors in flow estimation procedures based on normalization for watershed size and also due to the proximity of the location of the weather station to the watershed and the flow gage. Differences may also be due to the effluent flow contributions to the stream.

Table 5.3 GWLF flow calibration statistics

Modeled Watershed	Simulation Period	R2 (Correlation) Value	Total Volume % Error
UT Chickahominy	4/1/91 - 9/30/002	0.5476	8%

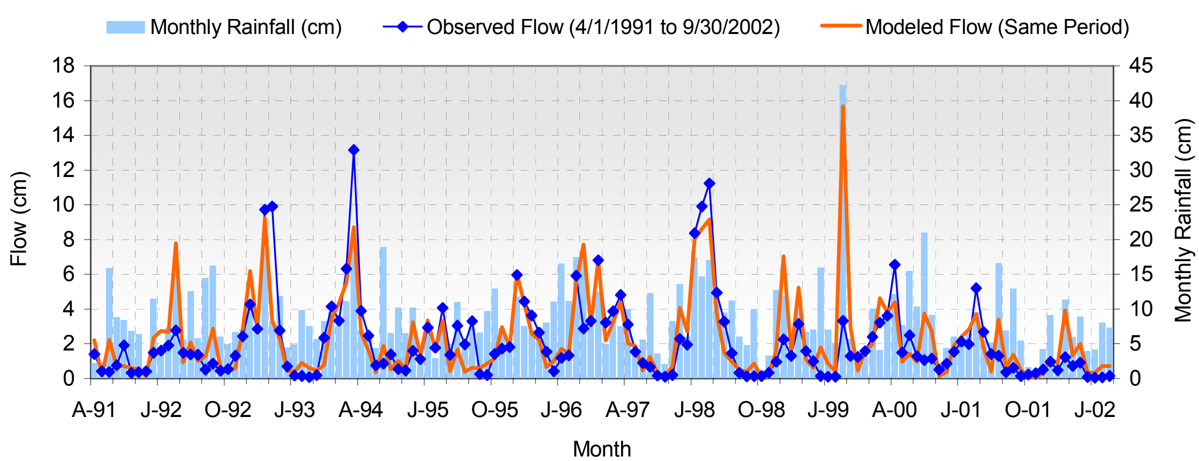

Figure 5.1 UT Chickahominy hydrology calibration using USGS gage 02036500

5.4 Wildlife Load Estimates

The nutrient loads contributed by wildlife to the impaired watershed were calculated using literature values for phosphorus loads in waterfowl feces (Manny et al. 1975). It was estimated that there are approximately 20 geese and 70 gulls that reside in the watershed. Loading rates of 0.36 lbs/yr of phosphorus per goose were used to estimate the annual nutrient loads contributed by waterfowl in the watershed. The load for gulls was based on the average weight difference between geese and gulls. It was estimated that the total annual phosphorus load from all waterfowl in the impaired watershed is 12.24 lbs/yr.

5.5 Point Source Load

The Tyson Foods Incorporated processing plant (VPDES VA0004031) is the only point source within the impaired watershed. The point source load from this facility was calculated using a design flow of 1.4 MGD and an average monthly concentration limit for phosphorus of 0.3 mg/L. The existing estimated load is 1,279.21 lbs/yr.

SECTION 6

TMDL METHODOLOGY

6.1 TMDL Calculation

For TMDL calculation the calibrated impaired watershed was run for a 12-year period from 4/1/1990 to 3/31/2002. Based on the weather and flow data it is assumed that this period sufficiently captures hydrologic and weather conditions. The 11-year means for pollutants of concern were determined for each land use/source category in the impaired watershed. The first year of the model run was excluded from the pollutant load summaries because the GWLF model takes a few months in the first year to stabilize. Model output is only presented for the years following the initialization year, although the model was run for a 12-year time period (4/1990 - 3/2002). The existing average annual phosphorus loads for UT Chickahominy are presented in Table 6.1. The phosphorus loads from wildlife (waterfowl) and the point source are included in this table. The loads from these sources were calculated as described in Section 5.

Table 6.1 Existing phosphorus loads in the UT Chickahominy watershed

Source Category	Phosphorus Load (pounds per year)	Sediment % of Total
Pasture/Hay	3.09	0.2%
Cropland	6.17	0.5%
Transitional	9.26	0.7%
Water	0.00	0.0%
Forest	0.44	0.0%
Urban	12.57	0.9%
Groundwater	9.04	0.7%
Point Source	1,279.21	96.0%
Wildlife	12.24	0.9%
Total Existing Load	1,332.02	100.0%

The TMDL established for UT Chickahominy consists of a point source wasteload allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS). The phosphorus TMDL for UT Chickahominy was based on the endpoint determined using a model developed by Reckhow (1988) as discussed in Section 5.2.

The TMDL equation is as follows:

$$TMDL = WLA + LA + MOS$$

The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis. An implicit MOS was included in the TMDL, using conservative assumptions.

The TMDL for UT Chickahominy was calculated by adding the watershed load for phosphorus together with the point source load and the load from wildlife to give the TMDL value (Table 6.2).

Table 6.2 Phosphorus TMDL for the UT Chickahominy

TMDL (lbs/yr)	LA (lbs/yr)	WLA (lbs/yr)	MOS (lbs/yr)	Overall % Reduction
432.69	23.34	409.35 (*Tyson Foods Incorporated*)	0 (implicit)	67.5%

6.2 Wasteload Allocation

A wasteload allocation was assigned to the point source facility in the watershed. The point source was represented by its current permit conditions and current permit requirements are not expected to result in attainment of the WLA as required by the TMDL. Therefore, reductions were required from the point source in order to meet the TMDL. The TMDL requires that the current phosphorus load from the Tyson Foods processing plant (1,279 lbs/yr) be reduced to 409 lbs/yr to achieve the required 67.5% reduction in the total phosphorus load (as shown in Table 6.2). This load corresponds with a concentration of approximately 0.1 mg/L of phosphorus in the point source discharge. * Load calculation: TP concentration (0.09599 mg/L - estimated) X design flow (1.4 MGD) X conversion factor (8.346) X 365 days/yr = 409 lbs/yr

6.3 Load Allocation

Load allocations were assigned to each source category in the watershed, based on the results of the Reckhow model. The recommended scenario for UT Chickahominy (Tables 6.3) is based on maintaining the existing percent load contribution from each source category. The recommended scenario balances the reductions from all sources by maintaining existing watershed loading characteristics. The loadings from source categories were allocated according to their existing loads distribution. For instance, nutrient loads from forest lands and groundwater represent the natural condition that would be expected to exist; therefore, the loading from forest lands and groundwater was not reduced. An additional scenario is presented for comparison purposes (Table 6.4). The point source was the only source to which reductions were made in this alternative scenario.

Table 6.3 Recommended phosphorus allocations for the UT Chickahominy

Source Category	Phosphorus Load Allocation (lbs/yr)	Phosphorus % Reduction
Pasture/Hay	0.99	68.0%
Cropland	1.98	68.0%
Transitional	2.96	68.0%
Water	0.00	0.0%
Forest	0.44	0.0%
Urban	4.02	68.0%
Groundwater	9.04	0.0%
Point Source	409.35	68.0%
Wildlife	3.92	68.0%
TMDL Load	432.69	67.5%

Table 6.4 Alternative phosphorus allocation scenario for the UT Chickahominy

Source Category	Phosphorus % Reduction
Pasture/Hay	0.0%
Cropland	0.0%
Transitional	0.0%
Water	0.0%
Forest	0.0%
Urban	0.0%
Groundwater	0.0%
Point Source	70.2%
Wildlife	0.0%

6.4 Consideration of Critical Conditions

The GWLF model is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Therefore, all flow conditions, including critical conditions, are taken into account for loading calculations. Because there is usually a significant lag time between the introduction of nutrients to a waterbody and the resulting impact on beneficial uses, establishing this TMDL using average annual conditions is protective of the waterbody.

6.5 Consideration of Seasonal Variations

The continuous-simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations.

The model requires specification of the growing season and hours of daylight for each month. The combination of these model features accounts for seasonal variability.

SECTION 7

REASONABLE ASSURANCE AND IMPLEMENTATION

7.1 TMDL Implementation

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of that effort for the benthic impairments on the UT Chickahominy. The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan, and to monitor stream water quality to determine if water quality standards are being attained.

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels in the stream. These measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the recent "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.state.va.us/tmdl/implans/ipguide.pdf. With successful completion of implementation plans, Virginia will be well on the way to restoring impaired waters and enhancing the value of this important resource. Additionally, development of an approved implementation plan will improve a locality or facility's chances for obtaining financial and technical assistance during implementation.

7.2 Reasonable Assurance for Implementation

7.2.1 Follow-Up Monitoring

VADEQ will continue monitoring at stations 2-XDD000.32, 2-XDD000.84, new station 2-XDD000.91 (in the tree line at permittee request), 2-XDD001.23, and 2-GRC000.96 in accordance with its biological monitoring program. VADEQ will also continue to sample for water temperature, pH, dissolved oxygen, conductivity, and nutrients at these stations and at 2-XDD000.40 (chlorophyll a at this station also). VADEQ will continue to use data from these monitoring stations and related ambient monitoring stations to evaluate improvements in the benthic community and the effectiveness of TMDL implementation in attainment of the general water quality standard.

VADEQ will continue to collect and evaluate data from ambient water quality stations on the

Chickahominy River at 2-CHK079.23 (Rt. 33) and 2-CHK076.59 (Rt. 625) bracketing the UT to Chickahominy River.

7.2.2 Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for a NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source. Nonpoint source controls to achieve LAs can be implemented through a number of existing programs such as Section 319 of the Clean Water Act, commonly referred to as the Nonpoint Source Program.

Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of DEQ, DCR, and other cooperating agencies.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ also submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

7.2.3 Implementation Funding Sources

One potential source of funding for nonpoint source TMDL implementation is Section 319 of the

Clean Water Act. Section 319 funding is a major source of funds for Virginia's Nonpoint Source Management Program. Other funding sources for implementation include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, the Virginia State Revolving Loan Program, and the Virginia Water Quality Improvement Fund. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

7.3 Link to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the Chesapeake Bay. The phosphorus reductions required under the wasteload allocation contribute directly to the nutrient reduction goals set as part of the Chesapeake Bay restoration effort. A new tributary strategy is currently being developed for the James River Basin to address the nutrient and sediment reductions required to restore the health of the Chesapeake Bay. Up-to-date information on tributary strategy development can be found at http://www.snr.state.va.us/Initiatives/TributaryStrategies/James.cfm.

Additionally, this TMDL is consistent with the special standards applicable to the Chickahominy watershed above Walker's Dam. As described in 9VAC 25-260-310, this standard requires effluent limitations of 0.1 mg/l monthly average for total phosphorus from all dischargers with the exception of Holly Farms Poultry Industries, now Tyson Foods Incorporated. This TMDL report shows that the exemption has resulted in negative impacts on the receiving stream. The TMDL proposed target is in line with the Chickahominy special standards.

SECTION 8

PUBLIC PARTICIPATION

A stakeholder and TMDL study kickoff meeting was held on April 4, 2003. A site visit to the UT Chickahominy was also conducted on this date. Important information regarding likely stressors and sources was discussed with state environmental personnel and local stakeholders.

The first public meeting on the development of TMDLs for UT Chickahominy was held on November 24, 2003 from 7-10 p.m. at the VADEQ, Piedmont Regional Office in Glen Allen, Virginia. 15 people attended the meeting (5 from VADEQ and 3 from GMU/Tetra Tech). Copies of the presentation materials were made available for public distribution at the meeting. VADEQ received written comments from the Complex Environmental Manager of Tyson Foods Incorporated on December 22, 2003.

The second public meeting on the TMDL development for UT Chickahominy will be held on March 17, 2004 from 7-10 p.m. at the VADEQ, Piedmont Regional Office in Glen Allen, Virginia. 14 people attended the meeting (8 from VADEQ and 3 from GMU/Tetra Tech). Copies of the Draft TMDL report and presentation materials were made available for public distribution at the meeting. No written comments were received.

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APPENDIX A

VADEQ December 2003 Monitoring

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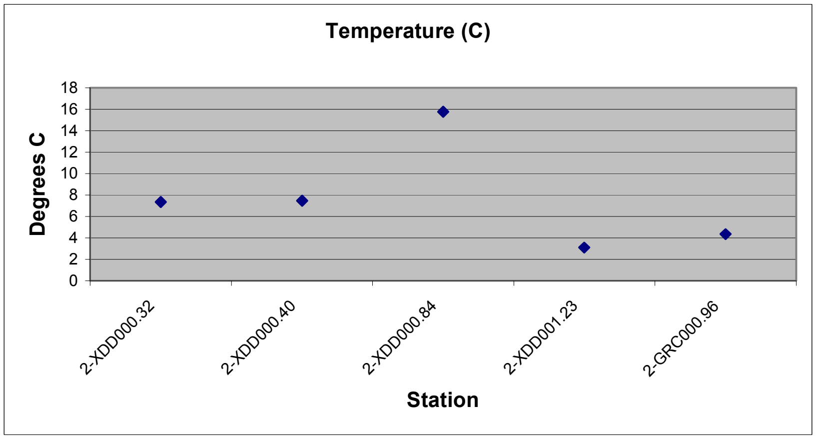

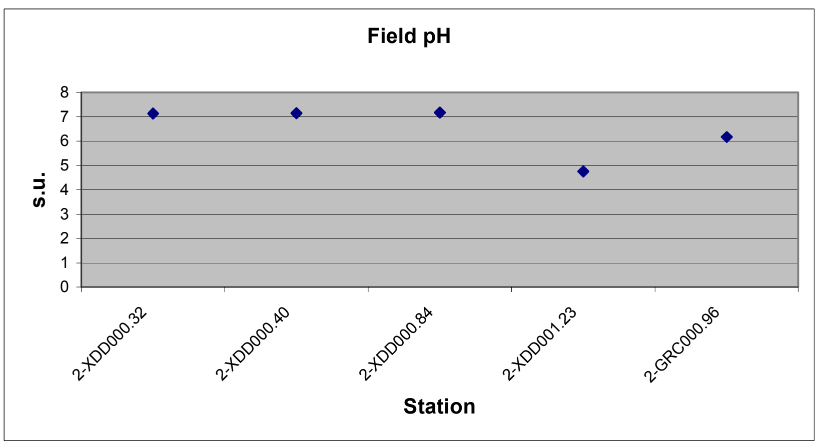

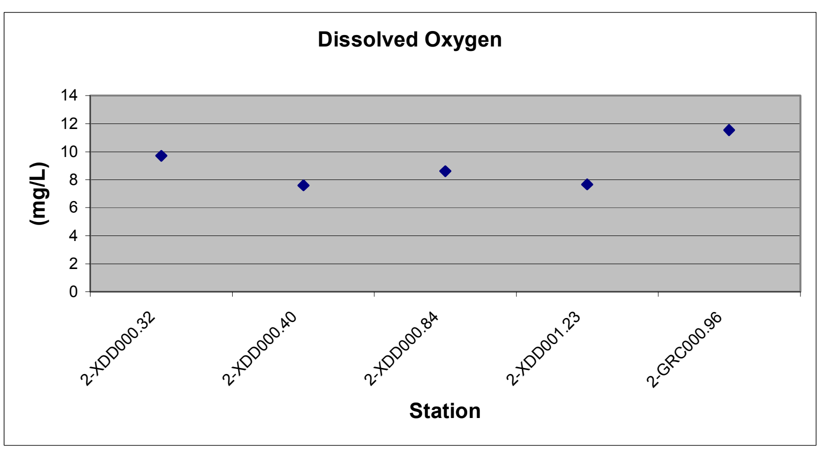

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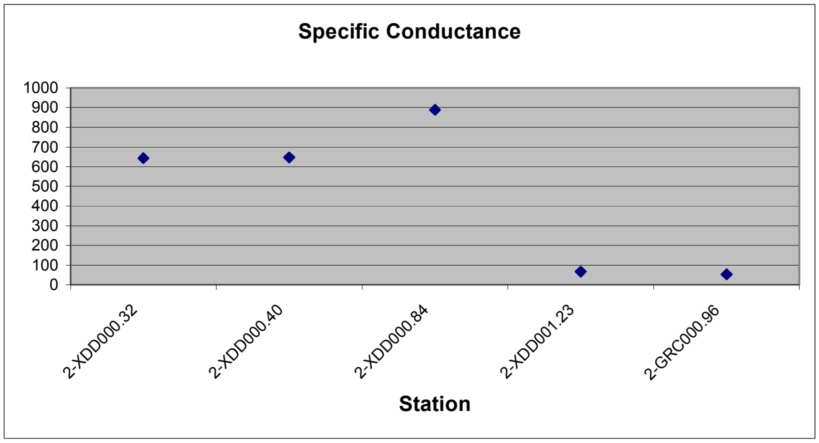

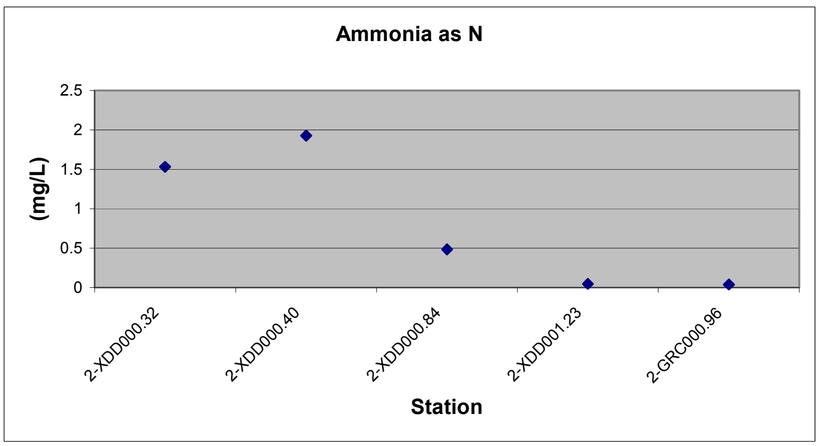

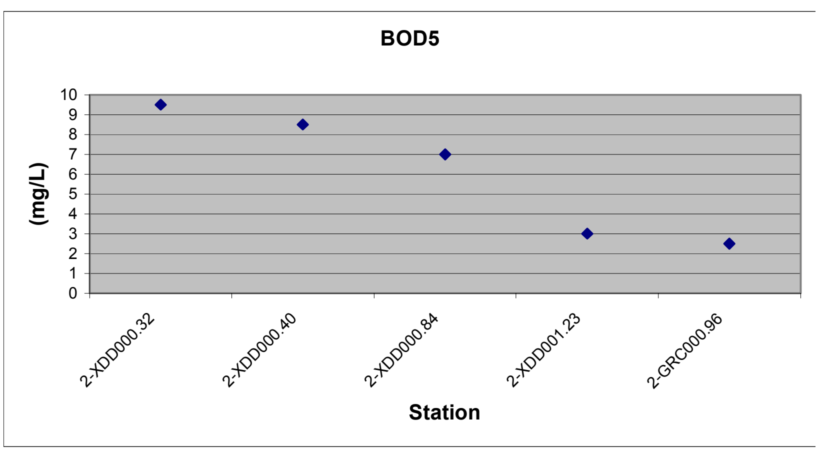

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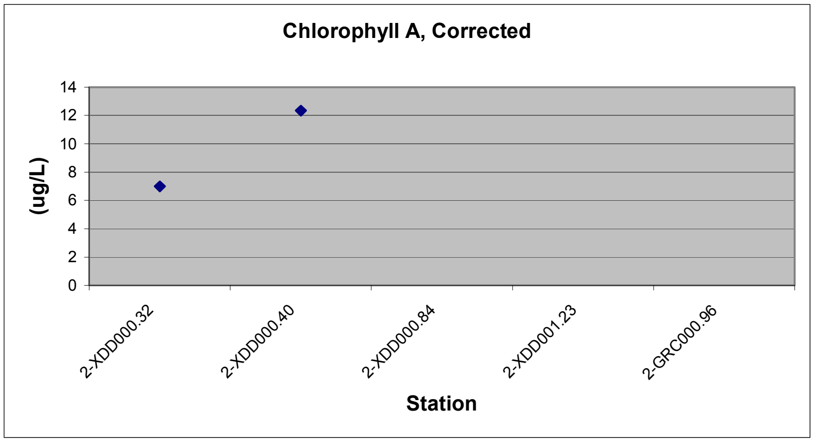

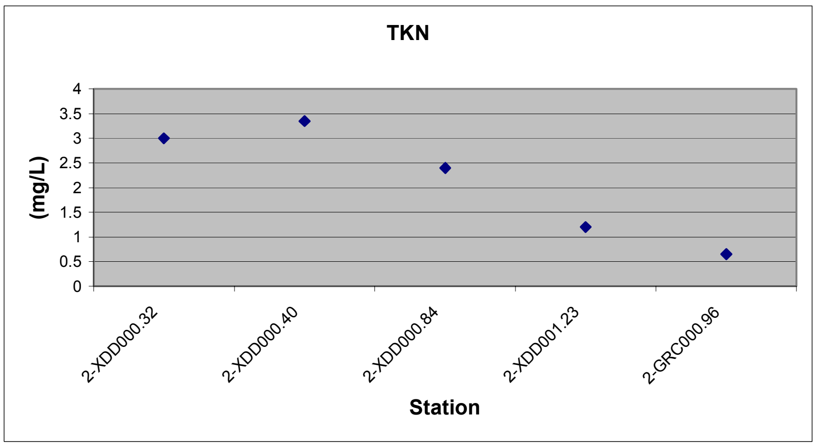

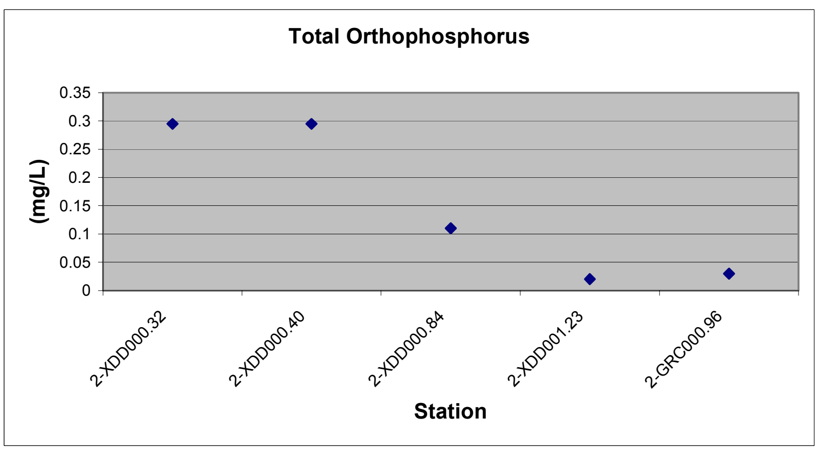

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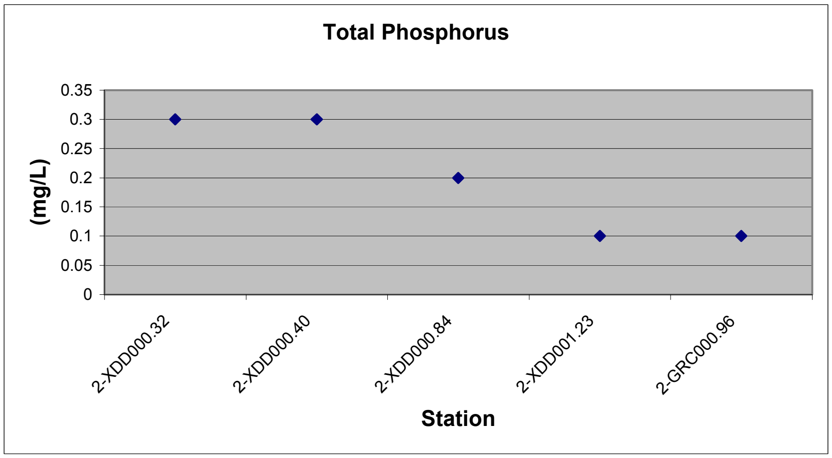
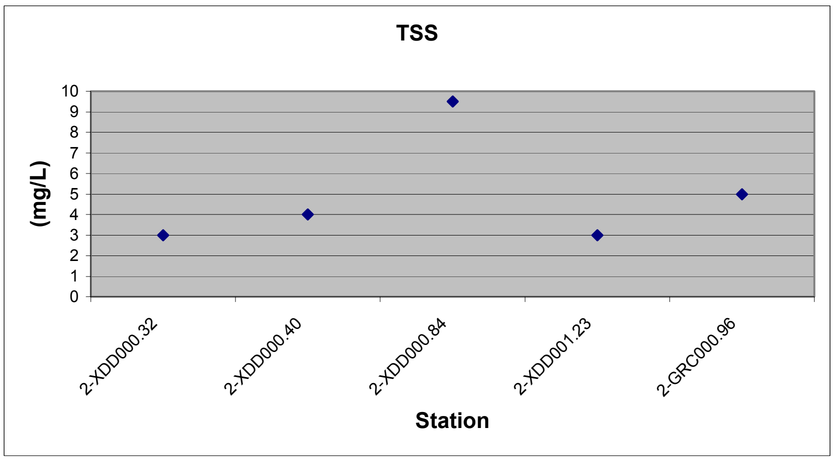
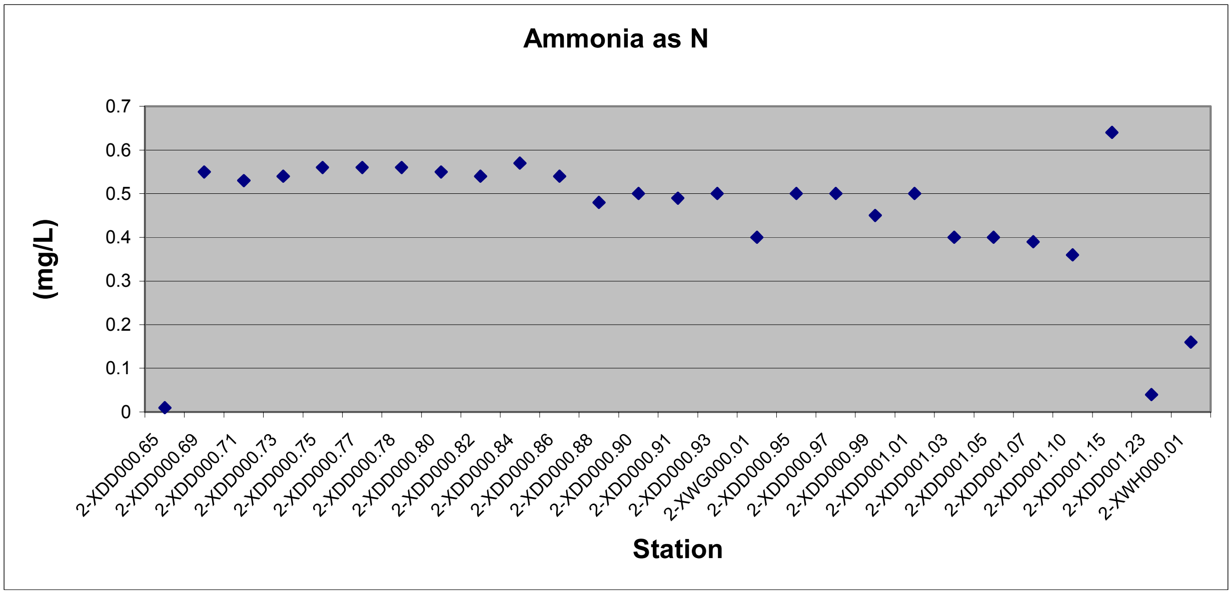
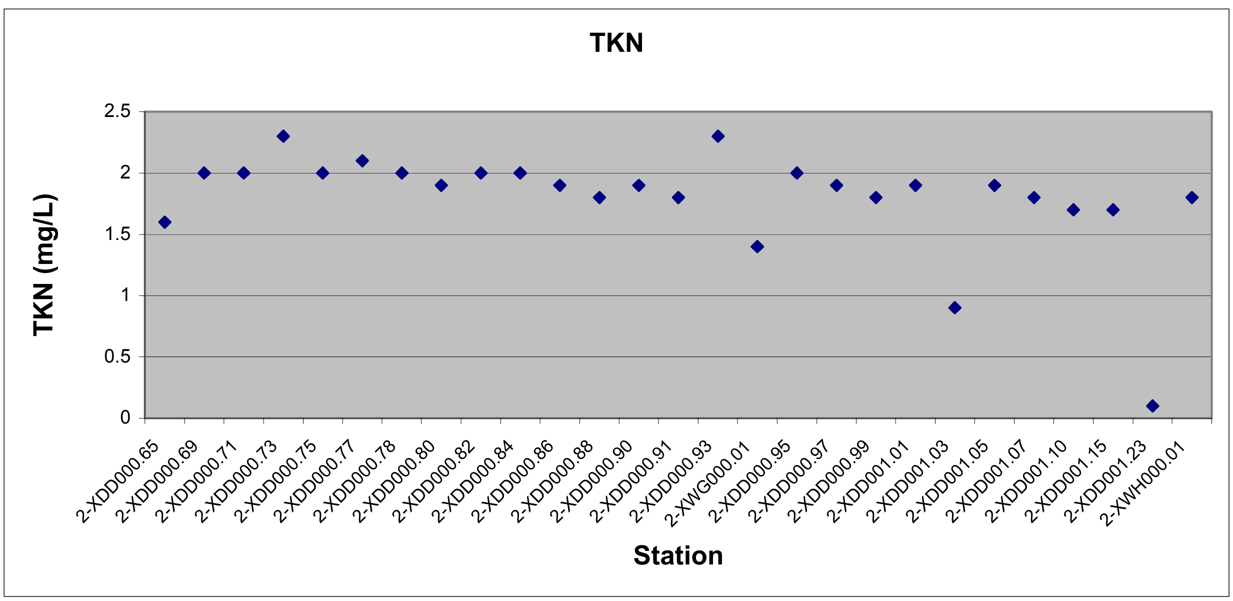


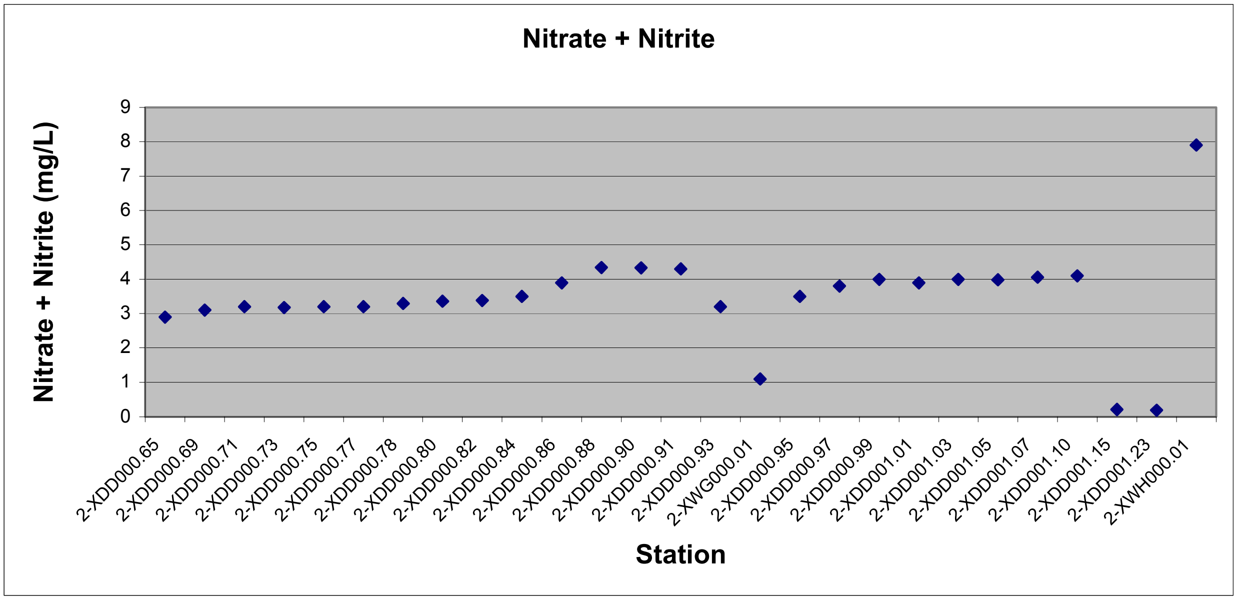


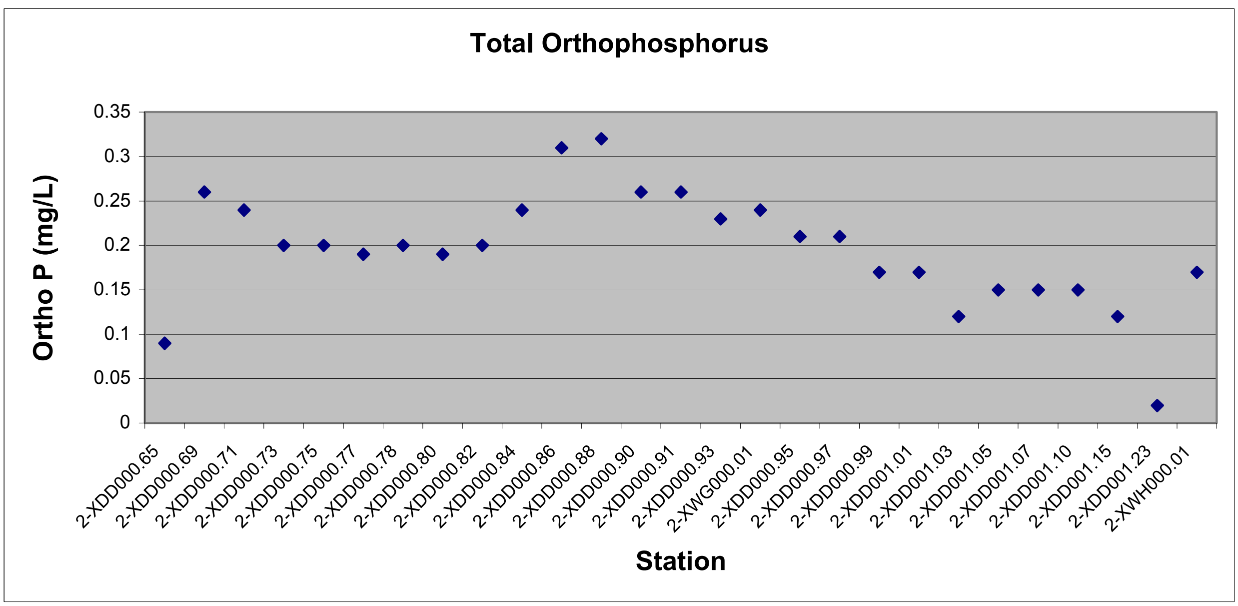
Sampled 12/5/03 - Storm 0.85 inches (stations are shown downstream to upstream)
* Station Key: 2-XWH000.01 (effluent), 2-XDD001.15 (below goose pond/Tyson parking lot), 2-XDD001.10 (below effluent discharge), 2-XWG000.01 (stormwater discharge), 2-XDD000.93 (below stormwater discharge/Tyson property line)





Sampled 12/5/03 - Storm 0.85 inches (stations are shown downstream to upstream)
* Station Key: 2-XWH000.01 (effluent), 2-XDD001.15 (below goose pond/Tyson parking lot), 2-XDD001.10 (below effluent discharge), 2-XWG000.01 (stormwater discharge), 2-XDD000.93 (below stormwater discharge/Tyson property line)





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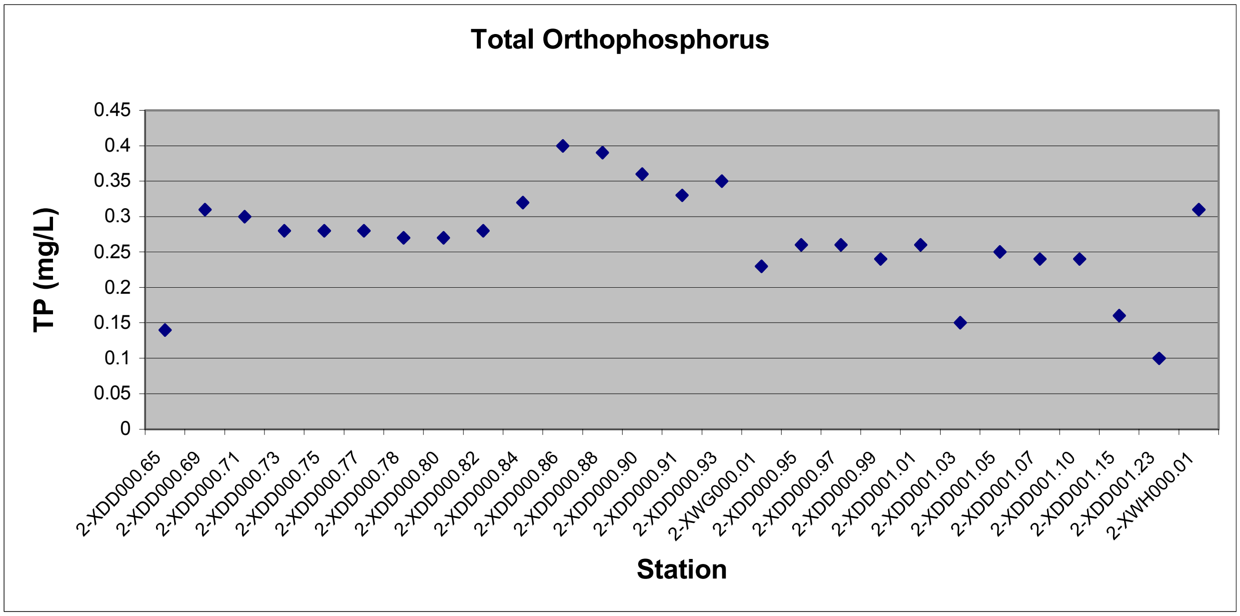

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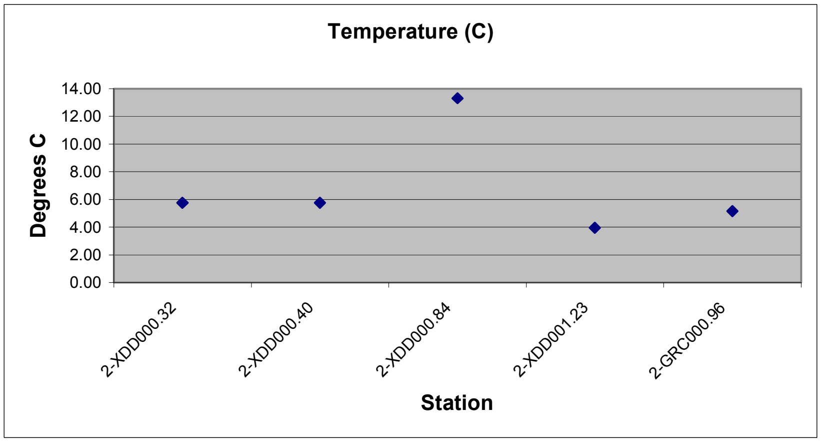

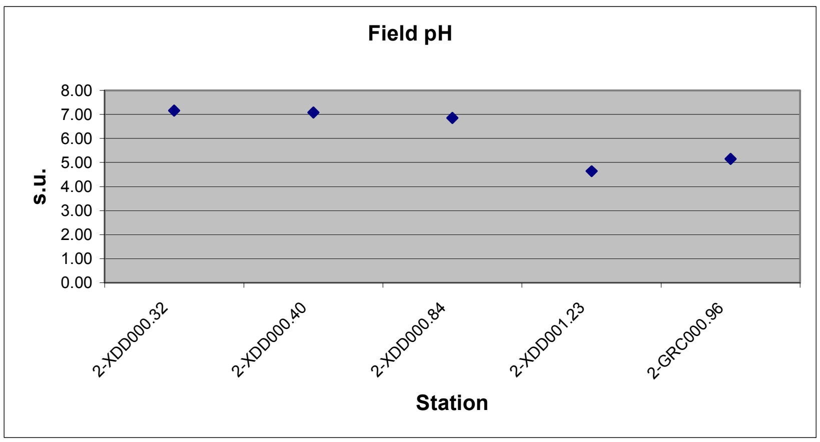

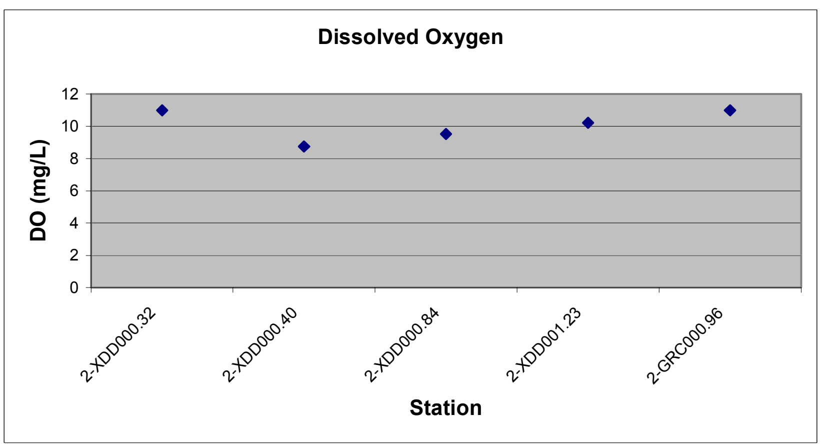

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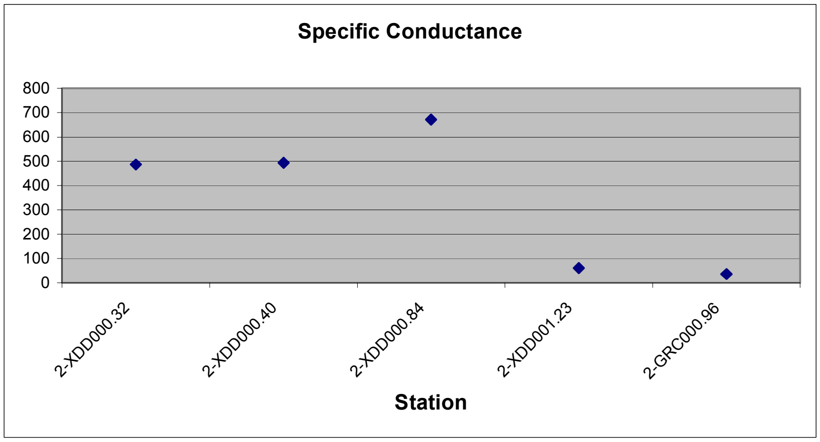

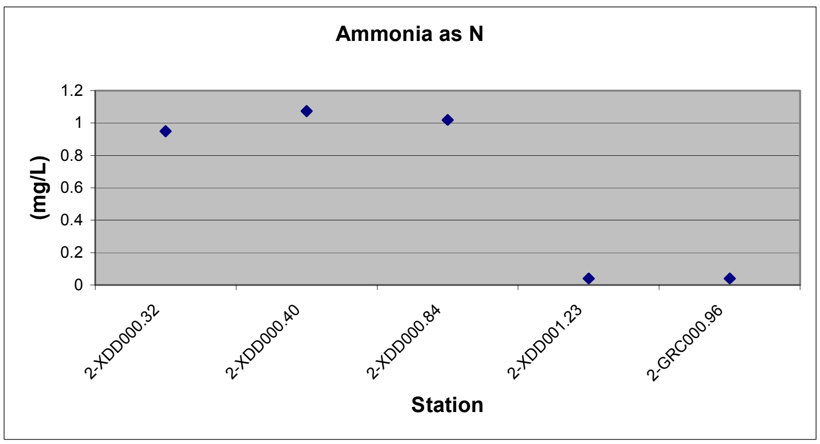

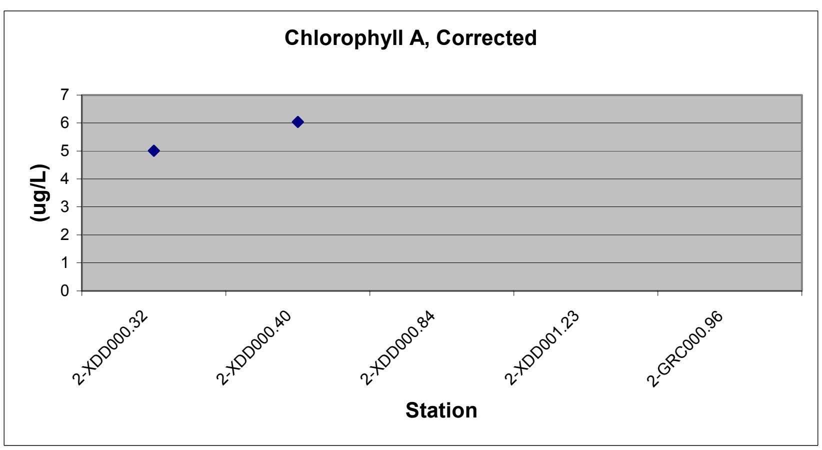

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